MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

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Captain W. DE W. ABNEY, C.B., R.E., D.C.L., F.R.S, President, in the Chair.

Major Archibald S. Drummond, Guards' Club, Pall Mall, S.W., and 117 Ashley Gardens, S.W.;
S. Maitland Baird Gemmill, care of W. L. Wilson, 254 St. George's Road, Glasgow; and
Samuel Arthur Saunder, M.A., Wellington College, and Fir Holt, Crowthorne, Berks,

were balloted for and duly elected Fellows of the Society.

Professor Albert A. Michelson, University Chicago, U.S.A.; and
Professor H. Poincaré, à l'Institut, Paris,

were balloted for and duly elected Associates of the Society.

The following candidates were proposed as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

J. J. Aubertin, 33 Duke Street, St. James', S.W. (proposed by Sir R. S. Ball);
Charles Josephus Greene, M.R.C.S., L.S.A., 10 St. Paul's Square, Preston, Lancashire (proposed by R. Wilding);
Frederic Hammond, F.R.I.B.A., Architect, 2 Mercers Road, Tufnell Park, N. (proposed by J. I. Berry);

William Harnett, Cullentra, Wimbledon Park, S.W. (proposed by John Browning) ;

Rev. Thomas Roseby, M.A., LL.D., The Parsonage, Marrickville, Sydney, New South Wales (proposed by R. T. A. Innes) ;

Rev. Peter Hately Waddell, M.A., B.D., The Manse, Whitekirk, East Lothian, Scotland (proposed by William Peck) ; and

Robert Wigglesworth, York (proposed by A. A. Common).

One hundred and eighty-four presents were announced as having been received since the last meeting, including amongst others :—

A series of sixty-one transparencies from negatives of Comets, Milky Way, &c., taken at the Lick Observatory, presented by E. E. Barnard ; S. W. Burnham, double star observations made with the 36-inch equatorial of the Lick Observatory, presented by the author ; Cape Observatory, heliometer observations for determination of stellar parallax, presented by the Observatory ; A. Cayley, Collected Mathematical Papers, vol. vii., presented by the author ; Cordoba Durchmusterung Catalogue and Atlas, presented by the Observatory ; a series of enlargements of photographs of the Moon, &c., and original negatives of *Jupiter* and *Saturn*, taken by the late Warren de la Rue, presented by Mr. Ernest de la Rue ; H. Deslandres, Collection of Papers, presented by the author ; J. L. E. Dreyer, Observations of Nebulæ, presented by the author ; J. G. Galle, Verzeichniss der Elemente der Cometenbahnen, presented by the author ; S. Glasenapp, Observations Astronomiques faites à Abastouman, presented by the author ; Greenwich Observations, 1891, presented by the Observatory ; J. E. Keeler Spectroscopic Observations of Nebulæ made at the Lick Observatory, presented by the author ; Laplace, Œuvres Complètes, tome x., presented by the Paris Academy ; Publications of the Lick Observatory, vols. ii. and iii., presented by the Observatory ; two photographs of the eclipse of 1893 April, presented by Comte de la Baume Pluvinel ; enlargements of lunar photographs, presented by W. Prinz ; Radcliffe Catalogue of 6,424 stars, presented by the Radcliffe Trustees ; A selection of photographs of stars, star clusters and nebulæ, by Isaac Roberts, presented by the author ; a box of lantern slides, presented by Dr. Roberts ; Robertson, Sectionum Conicarum libri vii., with MS. notes by F. Baily, presented by E. B. Knobel ; The Collected Mathematical Papers of H. J. S. Smith, edited by J. W. L. Glaisher, 2 vols., presented by the delegates of the Clarendon Press ; Webb's Celestial Objects, new edition, vol. ii., presented by the publishers ; Wilson and Gray, Investigations on the effective Temperature of the Sun, presented by the authors.

Note on Mr. Stone's Theory of the Measure of Time.
By Professor Simon Newcomb.

The discussion with Mr. Stone has now reached a stage where nothing remains to be done on my part except to invite Mr. Stone's attention to the conclusions from his theory, as he states them in the May number of the *Monthly Notices*.

A copy of Le Verrier's *Tables du Soleil* has been in my possession since the year 1859. If, with the tables in this book, I compute the sidereal time of mean moon on 1892, January 6, and thence the tabular right ascension of the Moon from Hansen's tables at the moment of its transit over the meridian of Oxford, on that date, I find a difference between the tabular and observed right ascension of $1^s.36$. The result will be substantially the same if I use the older tables of Carlini.

Mr. Stone maintains that this result is due to my failure to apply a certain correction to the numbers of Le Verrier's tables, which correction is not a function of anything contained in the tables, or of the epoch of any natural event, but of the date when a certain office, three thousand miles away, began to use the tables in computing the solar ephemeris. In his last note on the subject he gives precision to this conclusion by stating explicitly that if the office in question had not begun the use of the tables until 1892, the result would have been $0^s.10$, instead of $1^s.36$. The statement is still further strengthened by his answer to my second question, that $0^s.10$ would also have been the result if Carlini's tables had been continued to the present time in the *Nautical Almanac* Office, though, if I make the computation with Carlini's tables *now*, I shall get nearly $1^s.36$, the same as with Le Verrier's tables. It thus seems, according to Mr. Stone's theory, that the results which I now get from tables are different from what they would have been had a change of tables not been made in the *Nautical Almanac* Office.

Note on the Lunar Theory. By Professor Ernest W. Brown, M.A.

The terms in Delaunay's expression for the longitude with arguments $2iD \pm l \pm l'$ (i a positive integer), and coefficients of the form $ee'f(m)$ converge in some cases very slowly as far as the series arranged in powers of m are concerned. I have lately calculated the terms of this form, and have obtained the results exhibited in Column II. of the table given below. The values given have been carefully verified, and are correct to the fourth place of decimals of a second :—

I. Argument.	II. B.	III. D.	IV.	V.	VI. B−D.
$l+l'$	−110″1758	−110″1368	−0″1213	$\frac{1}{3}$	−0″0390
$2D-l-l'$	+206 8242	+207·0770	−0·3488	$\frac{2}{3}$	−0·2528
$4D-l-l$	+ 4·0861	+ 4·0312	+0·2074	$\frac{1}{3}$	+0·0549
$6D-l-l$	+ 0·0545	+ 0·0188	+0·0188	...	+0·0357
$8D-l-l'$	+ 0·0006	...	...	...	...
$2D+l+l'$	− 2·6612	− 2·6670	−0·0163	$\frac{2}{3}$	+0·0058
$4D+l+l'$	− 0·0370	− 0·0290	−0·0146	...	−0·0080
$6D+l+l'$	− 0·0004	...	...	...	...
$l-l'$	+149·1996	+148·3768	+0·8490	$\frac{1}{2}$	+0 8228
$2D-l+l'$	− 27·8714	− 29·2689	+1·4294	$\frac{1}{2}$	+1·3975
$4D-l+l'$	− 0·5780	− 0·7446	−0·0178	$\frac{1}{2}$	+0·1666
$6D-l+l'$	− 0·0078	− 0·0040	−0·0040	...	−0·0038
$8D-l+l'$	− 0·0001	...	...	...	...
$2D+l-l'$	+ 13·6294	+ 13·6278	+0·1526	$\frac{2}{5}$	+0·0016
$4D+l-l$	+ 0 2160	+ 0·1722	+0·0717	$\frac{3}{4}$	+0·0438
$6D+l-l'$	+ 0·0027	...	...	...	...

The columns numbered I.–VI. are as follows :—

I. The arguments in Delaunay's notation.

II. The results of my calculations. (These are obtained by using the numerical values of m from the start and inserting Delaunay's values of e and e' at the finish.)

III. Delaunay's values for the portions of the form $ee'f(m)$ as given in vol. xxix. of the *Memoirs of the French Academy of Sciences* on pp. 804, 805, 818, 819, 822, 823, 838, 839, 845, 846.

IV. The values of the last terms of the series in powers of m calculated by Delaunay to obtain the values in III.

V. The approximate ratio of the last group of terms of the same sign in Delaunay's series in powers of m. (See below.)

VI. The differences between columns II. and III.

Column V. is of importance as showing how an estimate can be made for the neglected terms in Delaunay's series. The series for any coefficient in the longitude all appear to have a common property which seems to be worth emphasising. In any coefficient we can pick out the terms of the form

$$e^i e'^j \gamma^p (a/a')^q (\alpha_0 + \alpha_1 m + \alpha_2 m^2 + \ldots)$$

where

$$\alpha_0, \alpha_1, \alpha_2 \ldots$$

are the positive or negative numerical multipliers. Then, in

nearly all cases, it will be found that (1) a series of the numbers,

$$\alpha_0,\ \alpha_1,\ \alpha_2 \ldots \alpha_r,$$

are of the one sign, followed by another series,

$$\alpha_{r+1}\alpha_{r+2} \ldots \alpha_s,$$

of the opposite sign, again followed by a third series,

$$\alpha_{s+1},\ \alpha_{s+2} \ldots \alpha_t \ldots,$$

of the first sign, and so on; the first change of sign may occur anywhere, but there are generally five or six terms at least before the sign changes again. (2) Whatever law governs these series, the natural result follows that the numerical multiplier on either side of the new sign is very small. (See *Monthly Notices*, vol. lii. p. 74.) (3) The terms of the series forming a group of the same sign have approximately a common ratio. Hence, if one of Delaunay's series has an approximately common ratio for the later terms, and if, in addition, the last term given do not fall in with this ratio, but is very small, we can accept it as very probable that the next term will be of the opposite sign, and can estimate the rest of the series accordingly.

A single example will illustrate these points, and will explain the only apparent discordance between my results and those of Delaunay as given in the table above. This is the coefficient of the term with argument $4D-l+l'$. Expressed in seconds, this coefficient is—

Term in $ee'm^3$...	$-0''.4750$
,, ,, $ee'm^4$...	-0.2518
,, ,, $ee'm^5$...	-0.0178
Sum	-0.7446
My coefficient being	-0.5780
Value of the rest of Delaunay's terms	$+0.1666$

showing that the terms must change sign.

The most important results are those for the coefficients of the terms with arguments $l-l'$ and $2D-l+l'$. The results show that an estimate with the common ratio $\frac{1}{2}$ would have given nearly the correct result.

Christ's College, Cambridge,
1894 *October* 27.

Notes on Solar Observations at Stonyhurst College Observatory.
By the Rev. W. Sidgreaves.

Drawings of Sun-spots and Faculæ.—In the summer of 1891 an arrangement was made for a tentative examination of the collection of drawings of Sun-spots and faculæ ; with the object, primarily, of ascertaining whether it could be considered probable that any trustworthy improvement might be made upon Carrington's measures of solar rotation; and, secondarily, of estimating by the experience of one year the labour of dealing with the work of a dozen.

For this purpose the period of least spot frequency—the year 1889—was selected, as offering a field of inquiry comparatively free from the entanglement of old with new growths. It was hoped that a careful study of the behaviour of the several groups both of spots and of faculæ during their lifetimes might lead to some systematic selection of least wandering landmarks that would be independent of that personal estimation of their stability necessarily employed by Mr. Carrington.

The reductions have been executed with extreme care by Mr. W. McKeon, to whom we are indebted also for nearly all the drawings made during the lifetime of the late Father Perry. The work was finished, after numerous interruptions, at the end of 1893. It contains complete tabulations of the heliographic positions of spots and faculæ, and of their deduced diurnal motions, seventeen charts of mean positions (including the winter months of the preceding year), four charts of daily positions, two charts of distribution in latitude, and one of "recurrences."

The heliographic positions have been read off the drawings by means of a transparent disc projection of the hemispherical lines of latitude and longitude, which has been carefully tested by comparison with the recorded positions of spots in the Greenwich Catalogues, and has been found to give the Greenwich measures within 0°·01 of longitude and 0°·10 of latitude.

The table of diurnal motions shows that the erratic movements of spots, even after the first commotions of formation have subsided, are so great that only a very long series of observations could be trusted for an amendment to the adopted period of the solar rotation. The slower rotation in higher latitudes, first noted by Scheiner in 1630, is clearly indicated ; but Carrington's law of this variation is hardly perceptible. Carrington also drew attention to the recurrence of spots in the same position. This tendency has been since observed by Secchi, Perry, and Maunder,* and we find it well marked in the year 1889. The chart of recurrences shows eight distinct regions where spots have reappeared after extinction, but we find no indication of per-

* *Le Soleil*, tome i. p. 142 ; *Astron. Register*, 1884 November, p. 252 ; *Monthly Notices of R.A.S.*, vol. l. p. 362.

manency in these regions—nothing to mark an area on the solar map as an irruptive region corresponding to our volcanic countries on Earth. They are, however, indicative of a more enduring state of disturbance than is measured by the lifetime of a single spot, for it is not improbable that a recurrence springs from the same source as its predecessor. And if this be true, the spots must be more subject to drift than their underlying origins, for nearly always the recurring spot is found to the rear of the former position.

The brighter patches of matter, known technically as faculæ, have been the more carefully studied since they were not included by Carrington in the work imposed upon himself. They have been treated in every way according to his method of estimating the motions of spots. Their greater extent of surface and their greater length of duration add much to the difficulty of identification at their several reappearances with the solar rotation. This is possible and comparatively easy at the minimum period ; but at times of greater solar activity the several groups of faculæ would become too entangled for separate treatment. On this account it would seem a hopeless task to measure the solar rotation by the motion of faculous groups at any other than the minimum period ; and no attempt has been made to carry on the work beyond the year 1889, although the results of this year show favourably in comparison with those obtained from the spots, and prove that the uncertain fixity of an adopted centre of a group is more than compensated by its much longer span of life. The average duration of a group of faculæ in 1889 was five times that of the companion spot.

The tabulated heliographic positions of the faculæ show that these are roughly subject to the same law of rotation-change as the spots. But the question of " lagging " seems to be left open. The appearances on the charts of faculæ and spots are decidedly in favour of the faculæ falling behind the spots in their march across the solar disc. Mr. McKeon, who has had the advantage of continous observation of the solar surface while sketching the spots and faculæ, is of opinion that there is no real change in the relative positions of the two : that the appearance is only the result of the previous extinction of the following member of a double spot, which has left its retinue of faculæ as attendants on the surviving and leading spot. In this way the survivor is left well to the front of a large group of faculæ, with the appearance of heading its way out of their midst. There can be no doubt that this history of the group robs the picture of the major part of the first-sight impression of lagging faculæ ; but when all allowance has been made for the extra appendages to the surviving spot, there is—to the writer, at least—some evidence in favour of a real falling back of the group of faculæ. But it is not clear whether this has been a gradual retardation, or whether it is to be attributed wholly to the leap forward of the leader, so often observed in the first days of a twin spot group.

The following table will serve to show the degree of probability we have for asserting that faculæ in general drift with the spots. Of the thirteen groups observed in the period, two were found in North Latitude at 5° and 7°, and all the rest appeared south of the Equator—viz. one at 2°, one at 3°, four at 8°, three at 9°, and two near 25°.

Mean Latitude.	No. of Groups.	Extreme Difference of Diurnal Motion.	Mean Diurnal Motion.	Carrington's No. for Spot Motion.
− 3°	2	8′	+15′	+13′
+ 6	2	8	+11	+11
− 9	7	32	+19	+ 8
−25	2	5	−13	−23

There is a very marked difference of motion indicated for the higher latitude; and it is sufficiently in accord with Carrington's law for the spots to warrant the conclusion that a great number of observations would establish, in general, the same law for both faculæ and spots. An extensive investigation of this nature might also result in a differential law for the two motions; for it cannot escape notice that the table shows nearly uniformly an accelerated drift of the faculæ as compared with Carrington's numbers obtained from the motions of spots.

The outline history of a group of spots and faculæ, as learned from the study of twenty-seven groups of 1889, may be given in a few words. First a few bright faculæ appear; in a day or two one or more black dots are seen in their midst; these rapidly increase along with the faculæ, and attain their full growth in about five or six days, while the faculæ continue to grow with the waning of the spot till they attain their fullest development at the extinction of the spot. At this epoch they begin to extend over a large area, steadily losing their lustre and falling off piece by piece, notwithstanding the frequent rekindlings amongst them by small newly-formed spots.

Of the parts of the outline history of a spot, the circumstances attending its birth are, no doubt, of the first interest in the connection of facts with theoretical explanation. The prior appearance of faculæ has been already noted in a communication to the *Monthly Notices* of 1891 December, where a full account was given of the nature of the evidence afforded by our drawings at this minimum period of solar activity. Further evidence was discovered later, and mentioned in the Report of the Council in 1893 February. And since then three other spots have been added to the list, making a total of nine observations of spots preceded by small bright faculæ. For six of these the evidence of precedence is complete, and for the remaining three only wanting as to the certainty of the complete extinction of the faded remains of a former group.

In the same report of 1893 February it was noted that two remarkable polar belts of small short-lived faculæ, unassociated with spots, appeared on the charts in latitudes 72° north and south. These deserve the additional remark of the observer that they were too clear to escape notice, although of less intensity than those of the lower belts, and left no doubt upon his mind of their reality. The extensive regions of faculous matter shown on the photographs at Paris and Chicago have led us to doubt whether the photographic charts will agree with our drawings in this respect. But we think that the marked way in which these little patches have caught the eye must claim for the high-latitude zones a distinctive character at the minimum period.

Photographic Plates of the Spectra of Sun-spots and Faculæ.—Our method of photographing the spectra of spots has been described in the *Monthly Notices* of 1893 February. We found after some experience with the enlarging lens mentioned in the same paper that the amount of light supplied by the double reflection from the two small mirrors of the heliostat was not enough for the enlarged image of a spot. The exposure became too long, and it was practically impossible to keep the spot sufficiently stationary on the slit for a satisfactory photograph. Our collection, therefore, of photographic plates of the spectra of sun-spots and faculæ has the disadvantage of showing only a very small band for examination; and we give the results rather as suggestions seeking correction or confirmation from better instruments than as facts established by our observations.

1°. Our plates of the yellow and green regions afford no trustworthy evidence of absorption lines widening over spots. There is, no doubt, an appearance of widening where the spot band crosses the spectrum, both on these plates and on those exposed to the violet rays; and this appearance is more striking on some contact positives than on the original negatives. But the appearances all but fail under the test of micrometer readings: the most that could be made of the strongest examples, with all bias in favour of the widening, was about $\frac{1}{100}$th of a millimetre, and from this we have to deduct something for the photographic widening, which, as pointed out by our President on a former occasion, is due to the feebler light of the spot, which is equivalent to a shorter exposure. An attempt was made to measure the amount of this deduction on some imitation spot bands obtained as described in our report in the last February number of the *Monthly Notices*. But the only conclusion we could formulate was that no certain difference of measurement could be made out, although the appearance of widening was more pronounced on the real spot bands than on their imitations.

The denser spots appear to stop out the photospheric radiation almost completely. On some plates exposed to one of the very dark spots crossing the solar disc in the first week of 1893 September, which bear the evidence of a steady image

during the exposures, the absorption lines can be seen crossing the spot band, but only with the aid of a slotted screen to stop out the rest of the picture; and on these we can find no appearance of widening.

2°. The double reversals of the calcium lines at H and K are greatly weakened over spots. This is so remarkable that it has appeared probable that over a full-grown spot there is no reversal of these lines, and that what is seen on some of the plates is only the effect of tremor of the image, on account of which a neighbouring bright facula often occupies its place on the slit and leaves its impression on the plate. On several plates which bear the marks of an unusually steady image, and which show a dense spot, the faculous reversals are nearly cut out by the spot band.

3°. In the immediate neighbourhood of a spot the bright reversals, if double at all, are usually only very feebly so, the central absorption being almost completely wanting, and the radiations thick and strong and closing up.

4°. At a distance from the spot the doubling of the reversal is more pronounced, and the bright components are thinner.

5°. There are traces on some plates of a continuous spectrum from the faculous matter, and occasionally this continuity is more marked through a range of a few tenth-metres on either side of H and K than elsewhere.

So far as these observations may be considered facts, they seem to be confirmations of the action in spot formation as given by the writer in a paper contributed to *Astronomy and Astro-Physics* of 1893 November. It was there noted that the precedence of small bright faculæ, in the order of time, was in favour of an uprush of heated gaseous matter, which, arriving at the higher elevations, radiated its light through a less depth of absorbing medium. The immediate result of this position of advantage for radiation would be the appearance of the bright lines of its constituents if they were not lost by projection upon the brilliant general spectrum of the solar light; but one of them escapes this obliteration owing to the dark background provided for it in the solar spectrum by the extensive absorption of calcium vapour,* and it is through the marks of this radiation on our photographic plates that we learn something of the history of these great luminous clouds. Their bright radiation shows where they are, but of itself leaves it uncertain whence they came. They must be above the reversing layer, and are certainly at a higher tem-

* Recently Monsieur Deslandres has shown the existence of other constituents in the bright faculous matter, by some beautiful photographs of their forms over the solar surface, taken with his double-slit spectroscope directed on an apparently dark iron line. The writer had the privilege of examining one of these plates on the occasion of its author's visit to Stonyhurst in the summer, and saw that the photographic map of the faculous matter obtained by iron radiation was substantially the same as the map given by the calcium light.

perature than their surroundings at their new elevation. They may have come up from below with the greater heat of a lower level, or they may have come from without and have been raised to a higher temperature by arrested motion. But they are at their highest elevation in the immediate vicinity of a spot, and lower at a distance from it; for close to a spot there is little or no double reversal, while away from it the central absorption is wide and strong—in other words, near a spot there is little or no superincumbent absorbing medium, while away from it there is much. For this reason it seems probable that the faculous clouds are thrown up from below, forming a rent in the solar atmosphere, where they leave a vast region of greatly reduced pressure and consequent chill, to account for the condensations which stop out the light from the photosphere and form the spot. They would attain their highest elevation directly over or near to the spot, and, drifting away, would gradually fall down. In the first days of its life the spot would be hidden from our sight by the bright faculæ directly over it; their nascent brightness would be enough to hide the spot in the telescope, and their partial continuous spectrum would mask its effect in the spectroscope. The spot would thus begin to appear as a dark speck in the midst of bright faculæ, and would grow to our vision as the faculous clouds uncover it falling down the slopes, like lava from a crater. This falling down is prettily shown on some of our plates by a V-shaped double reversal with the apex close to the spot band, and on others by a double V- or X-shaped reversal cut by the spot band through the centre. At the higher elevation the incandescent vapour is less dense and its radiation is narrower; falling, it becomes denser; its radiation is wider, but it is divided by greater central absorption.

Photographic Curves of Magnetic Variations, and their Connection with Solar Disturbances.—A comparison between terrestrial magnetism and solar surface disturbances, during the same period of least solar activity, shows a complete lack of agreement between them. With the charts of the solar surface, and the daily magnetic curves, to refer to, it was an easy task to pass in review the Earth's magnetic condition at every arrival of a group of spots and faculæ at the central meridian, or at the eastern or western limbs of the Sun. This was carefully done for three of the most disturbed regions, and the results were so contradictory of any supposable law that it was considered useless to continue the examination in this way. The converse method was then followed. A list of the greater magnetic disturbances furnished the dates for comparison with the sun-spot charts; and it was found that not only no condition, age, or position of spots or faculæ could be divined from the magnetic variations, but also that the greatest magnetic disturbance of the twelve months occurred at a time of complete and prolonged calm on both hemispheres of the solar surface. These magnetic perturbations

began about 6 P.M. on November 26, lasting through the night, and were repeated the two following nights, beginning a little later each night. Our own evidence of the solar calm at this time is nearly complete, and shows that no spot appeared on the surface of the Sun between the middle of October and the middle of December; and the absolutely complete daily record of the solar surface given in the Greenwich volume of 1889 from observations at the Royal Observatory, and those of India and the Mauritius, show the same complete calm. It must, therefore, be considered certain that, whatever connection there may be between some sun-spots and our magnetic disturbances, the one is not the cause of the other, and there are causes of the one which do not affect the other. At present we can go no further than admit that there may be some common cause of both phenomena, and that at one time the Earth is more within its reach than the Sun; at another, the Sun is nearer to its influence than the Earth. This common cause may be some form of cosmical stuff crossing our planetary system. There might be times in our history when we encounter it in greater quantities, and these times might occur periodically. We should then have greater and more frequent solar disturbances, and greater and more frequent magnetic storms, but not necessarily synchronously. This periodicity seems to be true, for we find more magnetic disturbances at periods of greater solar activity.

We are in need of other evidence of the existence of this cosmical stuff, and herein is our weakness. If it exists, we are too near it to see it. Many of the cloud forms which grace our skies would vanish into apparent nothingness on a near approach to them. We are probably too near the Zodiacal light to make much of our observations of its behaviour, and so this cosmical stuff would, if it actually exists, elude our notice.

Stonyhurst College Observatory:
1894 *November.*

Photographs of the Nebulæ H I. 84, *h* 1442, *and* H II. 344 *Comæ Berenicis.* By Isaac Roberts, D.Sc., F.R.S.

The photograph of the nebulæ H I. 84, *h* 1442, and H II. 344 *Comæ Berenicis*, R.A. $12^h\ 45^m$, Decl. north 26° 5′, was taken with the 20-inch reflector on 1894 May 7, with exposure of the plate during 90 minutes, and the two copies now presented are enlarged, one to 1 millimetre to 24 seconds of arc, and the other to the scale of 1 millimetre to 6 seconds of arc.

The nebula H I. 84 is No. 4725 in the *New General Catalogue*, and 3249 in the *General Catalogue*, where it is described by Sir J. Herschel as very bright; very large; extended; very suddenly very much brighter in the middle, with a bright nucleus.

Lord Rosse (*Observations of Nebulæ and Clusters of Stars*, p. 121) records six observations of the nebula between 1850 and 1867, and describes it as another spiral with two arms and some stars in the *following* arm; the centre is bright; 12 minutes *preceding* and a little *south* is another nebula (*h* 1442) elongated; and 30 minutes *north following* is a third, elongated *north* and *south*.

The nebula (H I. 84) is by Lord Rosse described as very large and very bright. The centre itself is like an elongated nebula with nucleus. This centre is enveloped in an irregular ring or rings of nebulous light, and he gives a rough marginal sketch of it.

The nebula *h* 1442 is described as very patchy and a faint nucleus suspected, with one faint star south of it.

The photograph shows the nebula H I. 84 to be a symmetrical ellipse and not a spiral, with the major axis in *north following* to *south preceding* direction, and the nucleus is a nebulous star of about 12th magnitude. Both the star and the nebulosity surrounding it have well-defined margins, the nebulosity having a ringlike boundary. Surrounding the nucleus, at a great distance, is a well-defined ring, but deformed on the *north following* side, and in the ring are involved several starlike condensations of nebulosity. Outside this ring is another faint ring symmetrical with it, but discontinuous on the *north following* side, and there is in it some evidence of nebulous condensations; there is also some indication of the existence of another very faint ring outside this. In the divisions between the rings are five well-defined stars of 15th to 16th magnitude, that may or may not be physically connected with the nebula. Several of the features which I have referred to must have been observed by Lord Rosse.

The nebula *h* 1442 is 54 seconds of time *preceding* H I. 84, and has a stellar nucleus surrounded by nebulosity which is elongated nearly in *north* and *south* direction, and has two faint condensations involved. It is a small, faint, elliptical nebula.

The nebula H II. 344 is $1^m\ 18^s$ *following*, and 17 minutes of arc *north* of 84, and has a small bright stellar nucleus and dense nebulosity elongated in *north following* to *south preceding* direction. There are two faint starlike condensations of nebulosity *south preceding* the nucleus.

Photograph of the Nebulæ H I. 143 and II. 536 Virginis.

By Isaac Roberts, D.Sc., F.R.S.

The photograph of the nebulæ H I 143 and II 536 *Virginis*, R.A. $12^h\ 55^m$, Decl. 3° 4′ north, was taken with the 20-inch reflector on 1894 April 9, with exposure of the plate during three hours, and the copy now presented is enlarged to the scale of 1 millimetre to 6 seconds of arc.

The nebula ♃ I 143 is No. 4900 in the *New General Catalogue*, and No. 3356 in the *General Catalogue*, and is described by Sir J. Herschel as considerably bright; considerably extended; star 10th mag., attached at about the position-angle 135°; four observations made. An engraving of the nebula is given in the *Philosophical Transactions* 1833, plate 14, fig. 67, but it does not well correlate with the photograph.

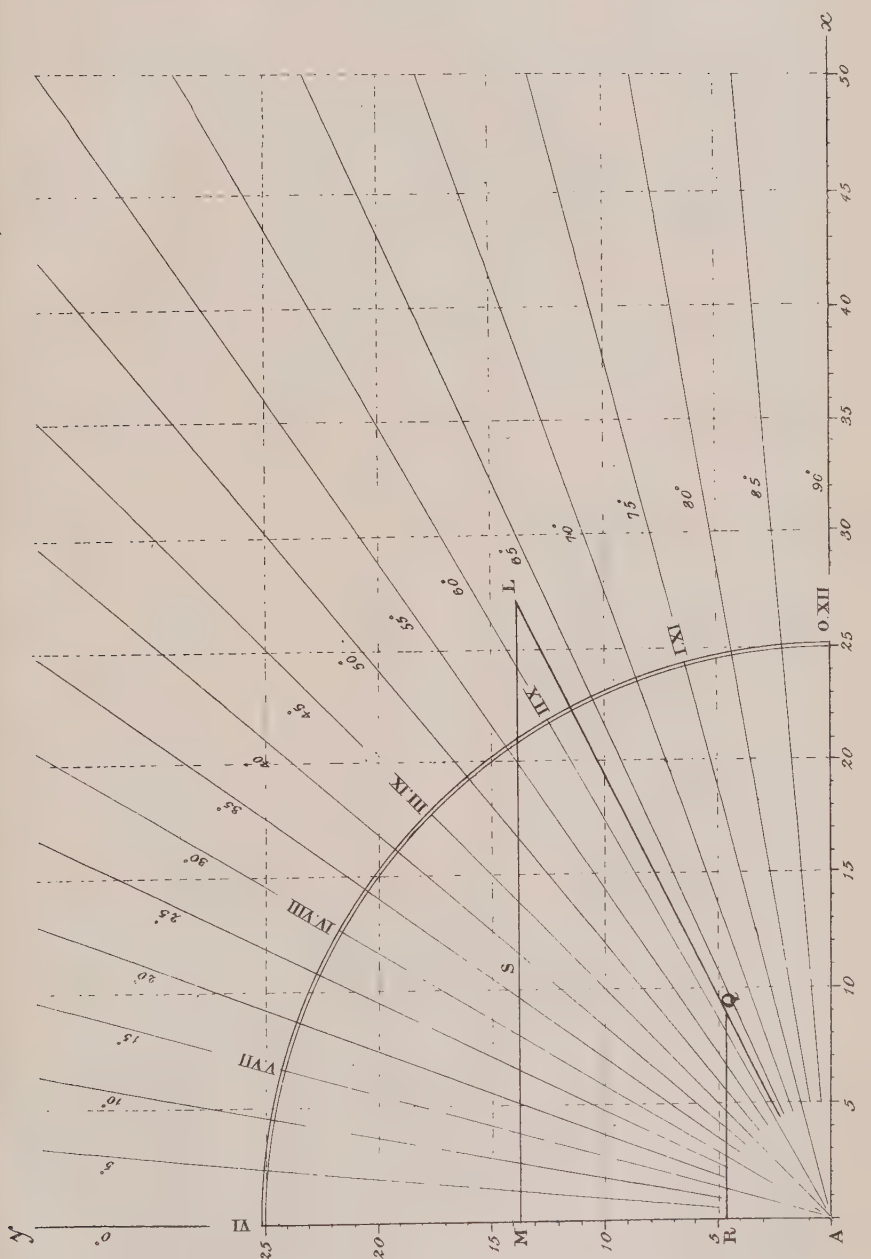
Lord Rosse (*Observations of Nebulæ and Clusters of Stars*, pp. 123, 124) records the results of seven observations made between 1855 and 1862, and he sometimes saw the nebula like the *Owl Nebula* (*h* 838), with a bright extended patch in the centre and dark spots on each side of this. Sometimes a dark ring is seen all the way round, but blackest to right and left (s.p. and n.f.). The nebulosity round is mottled, and he thought that sometimes he saw it as a spiral with a break in the outer annulus. "The darkness north of the nucleus (which is faint) certainly exists." A marginal sketch is given, but it does not resemble the photograph, except in the part which is circular in outline.

The photograph shows the nebula to somewhat resemble the letter D, with the curved side in *north preceding* direction, and a star of about 15th magnitude in the centre of curvature, the interior being filled with nebulosity of different densities, within which are five or six starlike condensations, and these give to the nebula the ring appearance referred to by Lord Rosse, but there is no spiral appearance visible in it as suggested by him. The less dense parts of the nebulosity are suggestive of dark lanes across the interior, but in reality they are the effect of contrast.

The *south following* part of the nebula is almost a straight line, with a star of about 13th magnitude close to it, but not in actual contact, and at sidereal time 10 hours on April 3 there was a minor planet* 317 seconds of arc *preceding*, and 317 seconds of arc *north* of the star above referred to. At sidereal time 10 hours on April 9 there was another minor planet at 57·83 minutes of arc *following*, and 383 seconds of arc *north* of the same star. The first of the minor planets would be equal to about 12th magnitude star, and the second to about 13th magnitude. I do not know if these planets have been previously discovered.

The nebula ♃ II. 536 is also shown on the negative.

* Dr. Downing has kindly searched and found this planet to be *Hecate* (100)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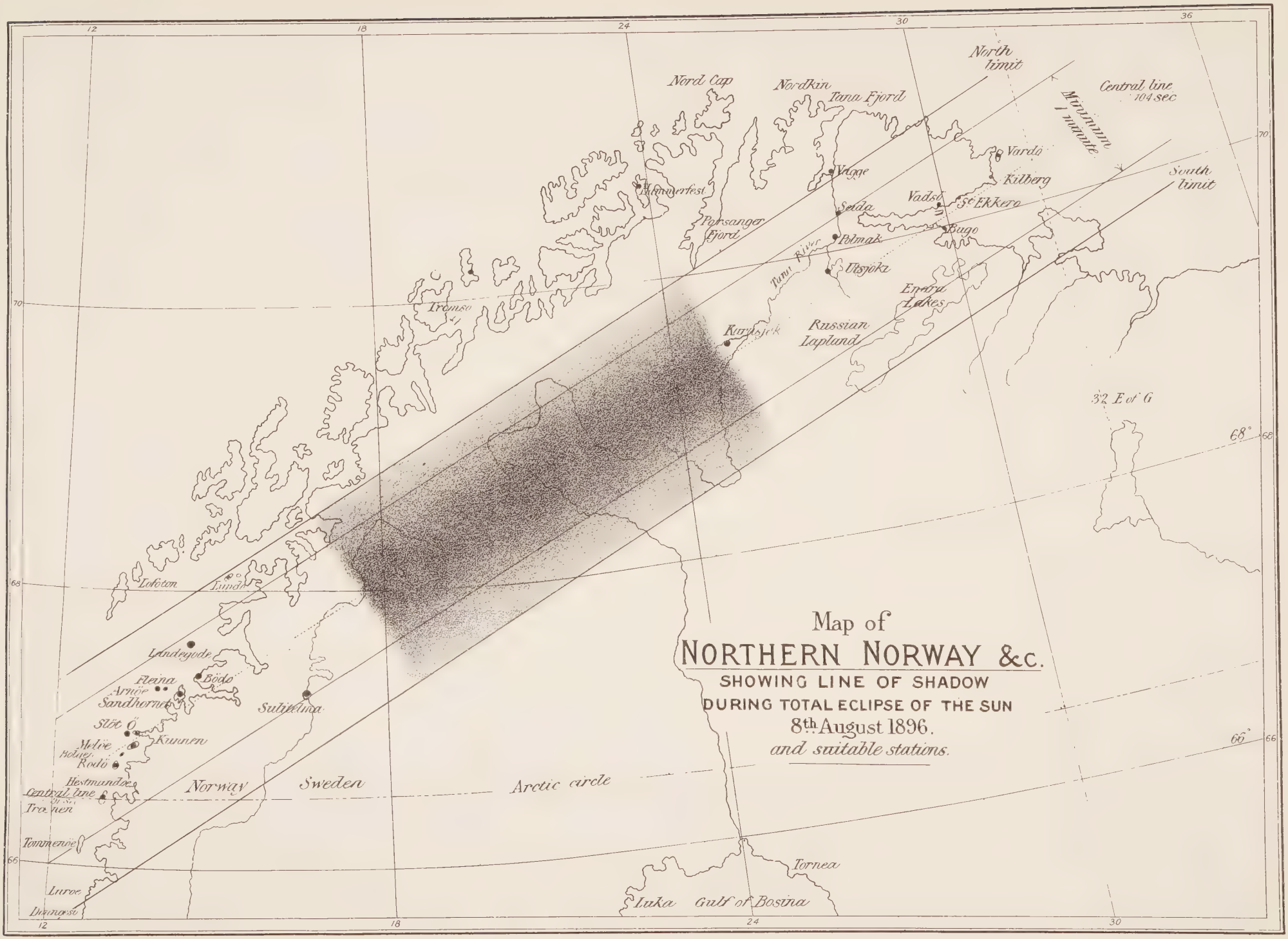


Map of NORTHERN NORWAY &c.

SHOWING LINE OF SHADOW DURING TOTAL ECLIPSE OF THE SUN 8th August 1896.

and suitable stations.

On the Computation of Star-corrections. By W. H. Finlay, M.A.

Professor Turner's paper in the April number of the *Monthly Notices* leads me to describe a diagram which I tried some years ago for computing star-corrections.

On squared paper a quadrant of a circle, with radius representing $25''$, is drawn, and is graduated to every degree by radial lines from the centre A (plate 1). These graduations also represent angles of four minutes of time at A. (Only a few of these lines are shown in the figure, so as to avoid confusion.)

Ax is the initial line for time from 0^h to 6^h; Ay for time from 6^h to 12^h and for declination.

The star-corrections are given by the formulæ

$$\Delta\alpha = f + g \sin (G+\alpha) \tan \delta + h \sin (H+\alpha) \sec \delta$$
$$\Delta\delta = i \cos \delta + g \cos (G+\alpha) + h \cos (H+\alpha) \sin \delta.$$

The first step is to form the sums $(G+\alpha)$ for all the stars observed on any particular day, and with the corresponding value of g as radius describe a quadrant of a circle about A. Let S be the point where the radial line corresponding to a certain star's $(G+\alpha)$ cuts the circle of radius g.

Through S draw MSL, parallel to Ax, to meet the line of the star's declination in L. Then

$$LM = AM \tan \delta = g \sin (G+\alpha) \tan \delta$$

and

$$SM = g \cos (G+\alpha).$$

After these terms have been obtained for all the stars, the sums $(H+\alpha)$ are to be formed and a circle of radius h drawn. For convenience I shall use the same circle as before on the diagram, and take S as the point where the radial line to $(H+\alpha)$ cuts the circle of radius h.

Take AQ along the declination line of the star and equal to SM. Then

$$AL = AM \sec \delta = h \sin (H+\alpha) \sec \delta$$
$$QR = SM \sin \delta = h \cos (H+\alpha) \sin \delta.$$

The values of $i \cos \delta$ can be easily obtained by drawing a similar circle of radius i on the diagram, or (if i be very small) they can be taken from a little table. The corrections, therefore, are

$$\Delta\alpha = f + LM + AL$$

and

$$\Delta\delta = i \cos \delta + SM + QR.$$

When g is smaller than $3''$ the first circle may be more conveniently described with a radius equal to $10g$, and the resulting values of LM and SM divided by 10. With a paper diagram it is not easy to avoid the formation of $G+a$ and $H+a$ for each star; but if the radial lines were ruled on some semitransparent surface and a graduated circle pivoted beneath it at A, then by turning this circle through an angle G, the values of the lines LM and SM could be read off at once with the argument a.

The chief merit of this diagram is that it gives the value of Δa directly instead of $\Delta a \cos \delta$.

When the declination is very large the lengths ML and AL become unmanageable, but with a scale of $2\frac{1}{2}''$ to the inch there was no difficulty in working to 70° declination. Beyond this point the R.A. correction can be easily obtained from the diagram in the form $\Delta a \cos \delta$, by proceeding in a manner somewhat similar to that described for the declination correction.

With this diagram star-corrections could be read in pretty rapidly; but, owing in great part to the imperfections of home-made scales, the results could not be depended on to within $0''{\cdot}2$. I therefore abandoned the diagram in favour of the tables described in *Monthly Notices*, vol. l. p. 497. These tables have been since completed, and have been in regular use at the Cape Observatory for the last two years. They are found to effect a saving of quite 33 per cent. in the time taken to compute star-corrections; they present no difficulty in working to quite inexperienced computers, and the results can be relied on to $0''{\cdot}03$.

The tables might have been compressed: the same value might have been chosen for g_0 and h_0, everything expressed in arc, and the R.A. correction obtained in the form $\Delta a \cos \delta$; but after long consideration I decided on the present form. It is desirable to get the R.A. correction at once in time instead of in arc; even the simple operation of turning arc into time, if repeated four or five thousand times in a year, means delay; so P and Q are tabulated in seconds of time. Up to 60° declination the variations of P and Q are practically uniform through the degree, but beyond that point this is not quite true. The variations given after that are average variations, and consequently there may arise errors of one or two thousandths of a second in allowing for the minutes of the declination. The proportional part of the variation for one degree which corresponds to any given number of minutes is taken at sight from a table.

Beyond 70° declination I have modified the tables. Instead of $g_0 \sin \theta \tan \delta$ and $h_0 \sin \theta \sec \delta$, I have tabulated $g_0 \sin \theta \sin \delta$ and $h_0 \sin \theta$. The sum of P and Q has now to be multiplied by $\sec \zeta$. Their variations for a degree are very small, and their values, allowing for the minutes of declination, can be taken straight out.

The tables may also be used for the computation of the effects of precession, aberration, and nutation on micrometrical measures of distance and position-angle.

The formula for precession in distance may be put in the form

$$\frac{\Delta\sigma}{\sigma \sin 1''} = h \cos (H+\alpha) \cos\delta - i \sin\delta$$
$$= h \cos (H+\alpha) \sin (90^\circ-\delta) - i \cos (90^\circ-\delta)$$
$$= Q' (1+y) - I$$

where Q′ and I are to be taken from the table for declination $=90^\circ-\delta$.

In position-angle we have

$$\Delta p = g \sin (G+\alpha) \sec\delta + h \sin (H+\alpha) \tan\delta$$
$$= g \sin (G+\alpha) \tan\delta \operatorname{cosec}\delta + h \sin (H+\alpha) \sec\delta \cdot \sin\delta$$
$$= 15\,P (1+x) \operatorname{cosec}\delta + 15\,Q (1+y) \sin\delta.$$

Cape of Good Hope:
1894 *October* 10.

Note on the Binary Star κ Pegasi (β 989). By T. Lewis, Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

κ Pegasi	R.A.	$21^h\ 39^m\ 53^s{\cdot}4$	1895·0
	N.P.D.	$64^\circ\ 58'\ 10''{\cdot}7$	

The small companion to κ *Pegasi* was noted in 1776 by Sir W. Herschel, and has been frequently measured as Σ 2824.

In 1880 August Mr. Burnham found the large star to be a close double (β 989). In the *Monthly Notices*, 1891 March, he gives all the measures and deduces a period of 11·13 years, thus making it the most rapid binary star known.

He remarks: "The extreme difficulty of measuring so close a pair seems to have deterred other observers, with a single exception, from doing anything with it. . . . It is unfortunate that we have so little to represent the extraordinary motion of this pair. . . . Since I have been at Mount Hamilton I have measured the close pair each year with the 36-inch refractor. During the measures of the past year it was extremely difficult, and was a severe test of the power of the great telescope with the very best atmospheric conditions."

This note naturally induced an inspection with the 28-inch refractor of the Royal Observatory, Greenwich, which showed them distinctly separated with a power of 1030, and our measures appear to confirm the remarkably short period.

The measures on the individual nights are :—

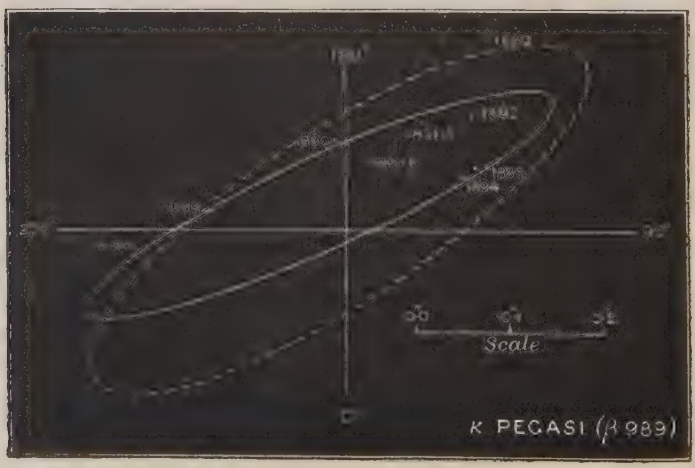
Date.	Position angle.	Distance.	Power.
	°	″	
1894, Oct. 27	108·5	0·114	840
„ 29	122·1	0·157	840
Nov. 6	115·0	0·133	1030
„ 21	113·6	0·152	1030

the position-angles being in each case the mean of five settings. On Oct. 27 and 29 the distances were estimated in relation to the thickness of the micrometer wires, the values for which on careful determination were found to be 0″·114 and 0″·134. On the other nights direct measures were made.

The following are all the measures, and they are plotted down on the same scale as employed by Mr. Burnham in the paper quoted above :—

	°	″		
1880·68	137·9	0·27	β	4*n*
1883·02	116·0	0·16	En.	1*n*
1887·78	274·7	0·23	β	3*n*
1889·51	262·3	0·14	β	4*n*
1890·57	187·1	0·10	β	4*n*
1891·61	150·0	0·10	β	3*n*
1891·81	144·6	0·13	β	4*n*
1892·39	132·8	0·18	β	4*n*
1894·83	114·8	0·14	L	4*n*

In the diagram shown below the dotted ellipse is that proposed by Mr. Burnham from his observations up to 1890, which would seem to want some modification to bring it more into accord with the recent measures. The narrower ellipse seems a nearer approximation to the apparent orbit.



The period is very nearly 11·6 years.

Mr. Burnham gives the magnitudes 4·3 and 5·0. As regards the distant Struve companion, the measures show rectilinear motion in the direction 72° of 0″·039 per annum; and if this is regarded as the proper motion of *κ Pegasi*, we have for this star a P.M. in

R.A. of + 0ˢ·0025

and in

N.P.D. of −0″·012

The measures are for Σ 2824—

1894·83 298°·8 and 12″·23.

The P.M. used for *κ Pegasi* is R.A. 000 and N.P.D. −0″·010 (Auwers). Bradley did not observe it in R.A.; but the Piazzi place gives P.M. in R.A. of + 0ˢ·0021.

Royal Observatory, Greenwich:
1894 *November* 2.

Since the above note was written I have found in *Popular Astronomy*, 1894 April, a discussion of this pair by Mr. Burnham, using his later measures, and another by Mr. Barnard, made with the 36-inch Lick refractor. His ellipse practically agrees with the one here given. The period he makes 11·37 years.

1894 *November* 8.

On the Orbit of η Cassiopeiæ (Σ 60).

By T. Lewis.

For various reasons this binary star is very interesting, and a better knowledge of its orbit seemed desirable. The following elements and notes are submitted in the hope that double-star observers will give it some attention.

The components are yellow and purple, and of the 4th and 7·6 mag. respectively.

The unusually large proper motion is in

R.A. +0ˢ·1346 and in N.P.D. +0″·481.

Its parallax has been determined by

Otto Struve	+0″·096	from measures of	distance
,, ,,	+0·373	,, ,,	position
Schweizer	+0·202	,, ,,	distance
,,	+0·139	,, ,,	position

A redetermination of parallax ought to be made.

The mean angular distance of the components is large (8″·4), and is only excelled by *Sirius* and *α Centauri*.

The orbits computed are

Computer.	Date.	P (years).	τ	e	Ω	γ	λ	a
					° ′	° ′	° ′	″
Powell	1861	181	1896·0	0·771	25 33	57 59	243 39	10·34
Dunér	1876	176·4	1924·8	·627	50 48	68 30	245 54	10·68
Doberck	1876	222·4	1909 2	·576	39 57	53 50	223 20	9·83
Grüber	1877	195·2	1901·3	·624	33 20	48 18	229 27	8·64
Coit	1882	167·4	1904·0	·622	41 2	52 5	233 6	8·70
Lewis	1894	208·1	1908·9	·500	47 6	47 36	214 10	8·45

It has, therefore, described over one-half its orbit while under observation, and there can be little doubt that the earlier computed dimensions of the orbit are too large.

Assuming the present elements, and adopting 0″·202 (the arithmetical mean) as the parallax, we find that the mean distance between the components is 41·84 times that between the Sun and the Earth, or 3,990,000,000 miles. *Neptune* is 30 times, or 2,760,000,000 miles.

Further, the combined mass is 3·54 that of the Sun, and the distance of the system from us is one million times the semi-diameter of the Earth's orbit.

Spectroscopic observations for motion in the line of sight would give further knowledge of this system.

I have compared the computed and mean observed places for each year, and although there are evidences of systematic error, there is a very fair agreement. As Mr. Coit published in *Monthly Notices*, 1882 May, a very complete set of observations, I think the following sufficient:—

Date.	Observed		Calculated	
	Angle.	Distance.	Angle.	Distance.
	°	″	°	″
1780·5	...	11·50	58·9	11.82
1782·5	60·1	...	60·2	11·87
1803·1	70·7	...	70·7	11·55
1819·8	80·2	10·80	79·9	10·63
1830·8	87·0	9·84	87·8	9·80
1840·4	96·2	8 95	95·8	8·93
1850·6	105·7	8 10	106 0	7·88
1860·6	116·8	7·02	119·4	6·90
1870·4	134·8	6·20	136·3	5·80
1880·3	160·2	5·30	159 6	5·31
1890·8	188·4	5·07	188·7	4·96
1894·1*	200·2	4·96	198·7	4·92

* I am indebted to Mr. Maw for this observation.

And an ephemeris for the next few years:—

1895·5	203° 3	4″·85	1898·5	212° 3	4″·75
1896·5	206·3	4 82	1899·5	215 4	4·70
1897·5	209·3	4·79	1900 5	218·4	4·64

1894 *November* 5.

A Comparison between the Results of the Radcliffe Catalogue of Stars, 1890, *and the Greenwich Results*, 1887–91, *contained in the Greenwich Five-Year Catalogue*, 1890. By E. J. Stone, M.A., F.R.S., Radcliffe Observer.

The Radcliffe Catalogue of 6,424 stars for the epoch 1890, which has just been distributed, and the Cape Catalogue for 1880, will afford positions of all the stars in the southern hemisphere of not less than the 7th magnitude, except those in clusters, and of fainter stars in those portions of the sky where there are no stars so bright as the 7th magnitude.

The Radcliffe Catalogue has been purposely made to overlap to a considerable extent the work of the Cape Catalogue in order to afford materials for a comparison of the results. A complete comparison of the positions of all the stars contained in these catalogues is nearly completed; the results show that the agreement both in right ascension and north polar distance between the Radcliffe Catalogue and the Cape Catalogue, 1880, is a very close one.

The comparison has also been extended to the stars common to the Radcliffe Catalogue and the Greenwich Catalogue for 1880.

These comparisons show that the north polar distance results of the Cape Catalogue fall between those of the two northern observatories, and that the differences are not large for either observatory. But the differences between the Radcliffe and Greenwich results are systematic, and are common to both the Greenwich Catalogue for 1880 and to the small catalogue of 258 fundamental stars, 1890 which has just been issued. I have given, therefore, in the present paper a table which shows the differences between the Radcliffe results and the Greenwich results for 1890 for the small catalogue of fundamental stars.

I need hardly say that all the corrections which I know to be necessary to clear the Radcliffe observations from systematic errors have been applied; but, of course, I do not expect that systematic errors have been entirely avoided. The differences between the direct and reflexion results found at Oxford have been too small, as may be seen on reference to the annual volumes for 1880-87, to render any corrections in this direction necessary; and the Radcliffe results are independent of *any*

empirical corrections. It is desirable to point out, what is certainly the fact, that the systematic corrections which have been applied to the Greenwich north polar distances for the "R—D discordance" are of the same order of magnitude and of sign as the discordances which exist between the Greenwich and Radcliffe results; and that the validity of the application of a correction of the form—constant × sine Z.D.—to the north polar distance observations when the constant used sensibly differs, as is the case at Greenwich, from that which is directly obtained for the horizontal flexure of the telescope, is, at least, very doubtful.

The corrections applied for R—D at Greenwich for some years past do not differ very greatly, and this proves that some such corrections are required to reconcile the *direct* and *reflexion* observations; but it certainly does not prove that such residual results can be correctly represented under the assumed form, and that they are applicable to the direct results, when the assumption appears to be negatived by the flexure observations.

The following table, extracted from the Greenwich volumes 1887–1891, gives the corrections applied to the direct north polar distance observations for those years, and these may therefore be taken as indicating the kind of corrections which have been applied to the results of the Greenwich 1890 Catalogue.

Correction for Discordance of Reflexion and Direct Results, Greenwich Observations.

N.P.D.	Corrections to Results of Direct Observations. 1887.	1891.
°	″	″
− 45	−0·69	−0·55
40	0·68	0·54
30	0·65	0·51
20	0·60	0·47
− 10	0·53	0·41
0	0·44	0·35
+ 10	0·34	0·27
20	0·23	0·18
30	−0·12	−0·09
40	0·00	0·00
50	+0·12	+0·09
60	0·24	0·18
70	0·34	0·27
80	0·44	0·34
90	0·52	0·41
100	0·59	0·46
110	0·63	0·50
120	0·66	0·52
+125	+0·67	+0·52
Horizontal Flexure.	−0″·06 sin Z.D.	+0″·06 sin Z.D.

The astronomical flexure of the telescope would, therefore, appear to be practically insensible, and quite inadequate to give rise to corrections such as those contained in the above table. It will be seen that in measuring directly a distance between the pole and the equator we have differences amounting to 0″·9, according as we apply or neglect these corrections.

I do not, of course, wish to assert that the discordances which exist between the Radcliffe and Greenwich observations are entirely due to the application of these corrections, or that the corrections applied at Greenwich are without warrant; but the discordances between the catalogues would certainly be much smaller if these corrections had not been applied, and the validity of the application of such corrections to the direct Greenwich results is, in my opinion, at least very doubtful.

The solar observations at Greenwich indicate that the Greenwich right ascensions should be increased; and this correction is in the direction indicated by the comparison between the Radcliffe and Greenwich observations so far as the stars in the northern hemisphere are concerned, but not for those in the southern hemisphere.

The comparison between the Radcliffe Catalogue, 1890, and the Cape Catalogue, 1880, show similar but much smaller changes of the differences in right ascension near the equator; and the mean differences between the Radcliffe and Cape Catalogues given by the general discussion are rather smaller than those indicated in the limited comparison here instituted through the stars common to the three catalogues.

Comparison between the Corresponding Results of the Radcliffe Catalogue of Stars for 1890 *with the Greenwich Five-Year Catalogue of* 258 *Fundamental Stars for* 1890.

	Limits of Group N.P.D.	Mean N.P.D. of Group.	Radcliffe minus Greenwich in R.A. × sin N.P.D.	Weight.	Radcliffe minus Greenwich in N.P.D.	Weight.	R−D applied to Greenwich Results.
	° °	°	s		″		″
1	−5–0	− 2	+0·001	422	−0·16	272	−0·38
	0–5	+ 2			+0·28	268	
2	6–22	15	−0·032	14	+0·23	36	−0·25
3	23–38¼	30	+0·009	19	−0·68	38	−0·11
4	38¼–58	50	+0·024	80	−0·78	80	+0·11
5	59–68	64	+0·040	257	−0·73	189	+0·25
6	69–78	73	+0·043	421	−0·83	279	+0·34
7	79–88	83	+0·035	550	−0·98	274	+0·42
8	89–98	93	+0·020	328	−0·87	177	+0·49
9	99–108	103	−0·020	295	−0·86	173	+0·54
10	109–120	114	−0·046	115	−1·16	76	+0·57

Procyon and *Sirius* have not been included in the comparison owing to their orbital motions, but the results would not have been sensibly affected if they had been included.

Comparison between the Results of the Radcliffe Catalogue, 1890, *and the Cape Catalogue*, 1880, *for the same Stars for Groups* 4, 5, 6, 7, 8, 9, *and* 10.

	Limits of Group N.P.D.	Mean N.P.D. of Group.	Radcliffe minus Cape Catalogue, 1880, in R.A.	Weight.	Radcliffe minus Cape Catalogue, 1880, in N.P.D.	Weight.
	° °	°	s		″	
4	$38\frac{1}{4}$–58	50	+0·031	30	−0·35	20
5	59–68	64	+0·052	199	−0·45	49
6	69–78	73	+0·046	358	−0·46	68
7	79–88	83	+0·037	509	−0·46	104
8	89–98	93	+0·028	414	−0·70	84
9	99–108	103	−0·007	323	−0·45	77
10	109–120	114	−0·005	250	−0·27	53

The weights of these comparisons and the accuracy of the mean differences are somewhat diminished from the comparatively few observations of the north polar distance of the northern stars contained in the Cape Catalogue, and the few southern stars contained in the Greenwich Catalogue, 1890.

The general discussion of the solar observations made at the Radcliffe Observatory gives with the latitude adopted in the General Catalogue a correction for the north polar distances of only −0″·015.

The comparisons here given show that the systematic differences between the Cape results and those of the two northern observatories are rather less than half a second of arc, and these differences include the errors of the refraction tables, with the effects due to different exposure of the thermometers, and any uncorrected division errors. The systematic differences between the different catalogues are certainly larger than could be wished, but a second of arc is only one ten-thousandth part of an inch on the Radcliffe circle.

Such comparisons as those here made appear to me to throw some light on the supposed inaccuracy of meridian observations.

When a sufficient number of observations are grouped together to reduce the errors of the refraction tables to mean errors, the results of the comparisons between the north polar distances contained in the Cape Catalogue of 1880 and the Greenwich and Radcliffe Catalogues lead to the following results :—

The observations contained in the Cape Catalogue, 1880, gave directly zenith distances, and they were referred to the south polar point, with a zenith distance of the polar point determined from observation, subject also to errors of determination, instrumental and reductional, including the errors of the refraction

tables with the *adopted* thermometer exposures. The southern observations thus gave independent south polar distances.

The corresponding observations included in the Radcliffe Catalogue, 1890, have given independent north polar distances subject to similar errors of zenith distance and of polar point.

These results are only comparable on the assumption that the angle between the polar points is *exactly* 180°. We are, therefore, when the observations are thus independently referred to the north and south polar points, measuring 180° when comparing north polar distances made at the northern and southern stations; and when, therefore, the mean differences between the northern and southern observations are confined within such limits as $\pm 0''.5$ we are practically obtaining results within the $\frac{5}{180\times60\times60\times10}$ part, or the $\frac{1}{1296000}$ part of the quantity measured. It remains to be proved that other astronomical methods are more accurate than meridian observations for the measurement of such large angles.

It is undoubtedly true that small angles can be measured with much greater accuracy by other methods; but when differential methods are adopted we have to guard against an accumulation of the effects of the errors made in passing by summation from the small angles directly measured to the larger angles with which we are concerned in practice.

Radcliffe Observatory, Oxford:
1894 *November* 8.

Comparison of the Pulkowa Catalogue, 1885, *with the Greenwich Ten-Year*, 1880, *and Five-Year*, 1890, *Catalogues.* By W. G. Thackeray, Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

The observations of the Pulkowa Catalogue for 1885 extend over the years 1882–1891, and are a continuation of the series of declinations made with the vertical circle at Pulkowa, of which the Catalogues for 1845 and 1865 are well known. Before the observations for the present catalogue were begun the vertical circle was thoroughly overhauled, the pivots re-turned, and the circle re-divided. The Catalogues for 1865 and 1885 are in all respects similar, and the observations are reduced with the same refraction and the same value of co-latitude. The results for 1885 have been further corrected for variation of latitude in accordance with a paper of M. Nyrén's in *Bulletin de l'Acad. de St-Pétersbourg*, N.S. III.

From a comparison with the results of the 1865 Catalogue, M. Nyrén concludes that the adopted refractions would be better for

a correction to the logarithm of the constant of refraction of $-0''.00121$, that is $\rho = 57''.358$, and an increase in the coefficient of the thermometer $dm = +0''.0001021$, or $m = 0''.0047121$ for 1° R, the general effect of the combined correction being to diminish the adopted refractions.

The Greenwich Catalogue, 1880, extends over the years 1877–1886, and the 1890 Catalogue from 1887 to 1891. The adopted value of the latitude, 51° 28′ 38″·1, is the same for both catalogues. The observations have been reduced with Bessel's refractions, and corrected for R—D by the formula $a+b\sin z$.

Auwers's proper motions have been used both at Greenwich and Pulkowa.

The stars common to the three catalogues are 167 in number, and the comparison has been effected by bringing up the Pulkowa places for 1885 to 1890 by using Auwers's P.M.'s, from his re-reduction of Bradley's observations, and the mean of the precessions as given in the Pulkowa and Greenwich, 1890, Catalogue. The differences exhibited are the apparent corrections to reduce the Greenwich Catalogues to Pulkowa.

For convenience we will call the Pulkowa Catalogue "P," and the Greenwich Ten-Year, 1880, G_X, and the Five-Year, 1890, G_V. Then

TABLE I.

Star's Name.	Approx. R.A.	N.P.D. Pulkowa 1885 reduced to 1890.	No. of Obs.	Secs. of N.P.D. 1890·0 deduced from 1887–1891 Greenwich Five-Year Cat.	No. of Obs.	Secs. of N.P.D. Greenwich Ten-Year Cat., 1880, reduced to 1890.	No. of Obs.	P−G_V	P−G_X
	h m	° ′ ″		″		″		″	″
α Andromedæ	0 3	61 31 1·08	23	0·61	34	0·86	42	+0·47	+0·22
γ Pegasi	0 8	75 25 41·34	16	40·96	19	41·35	32	+0·38	−0·01
ι Ceti	0 14	99 26 2·14	12	1·82	14	2·20	20	+0·32	−0·06
ε Andromedæ	0 33	61 17 8·50	9	7·84	15	8·54	25	+0·66	−0·04
α Cassiopeiæ	0 34	34 3 57·84	44	58·68	6	58·30	31	−0·84	−0·46
β Ceti	0 38	108 35 25·85	29	26·38	14	26·17	25	−0·53	−0·32
μ Andromedæ	0 51	52 5 50·84	8	50·61	9	50·78	28	+0·23	+0·06
ε Piscium	0 57	82 42 8·11	8	8·97	10	8·54	47	−0·86	−0·43
β Andromedæ	1 4	54 57 46·31	8	46·19	22	45·89	52	+0·12	+0·42
Polaris	1 18	1 16 41·73	719	41·54	626	41·63	1433	+0·19	+0·10
θ Ceti	1 19	98 45 4·34	10	4·74	4	4·41	11	−0·40	−0·07
η Piscium	1 26	75 13 17·71	9	17·38	14	17·52	34	+0·33	+0·19
ο Piscium	1 40	81 23 46·44	10	46·11	25	46·52	28	+0·33	−0·08
ζ Ceti	1 46	100 52 43·95	10	43·69	7	43·97	8	+0·26	−0·02
ε Cassiopeiæ	1 46	26 52 19·53	26	19·06	7	19·81	40	+0·47	−0·28

Star's Name.	Approx. R.A.	N.P.D. Pulkowa 1885 reduced to 1890.	No. of Obs.	Secs. of N.P.D. 1890·0 deduced from 1887–1891 Greenwich Five-Year Cat.	No. of Obs.	Secs. of N.P.D. Greenwich Ten-Year Cat., 1880, reduced to 1890.	No. of Obs.	P−G$_V$	P−G$_X$
	h m	° ′ ″		″		″		″	″
β Arietis	1 49	69 43 48·10	10	47·80	26	48·11	66	+0·30	−0·01
γ Andromedæ	1 57	48 11 54·68	12	54·07	4	54·16	32	+0·61	+0·52
α Arietis	2 1	67 3 29·32	35	29·03	25	29·30	72	+0·29	+0·02
ξ^2 Ceti	2 22	82 2 0·39	10	0·33	19	0·17	25	+0·06	+0·22
δ Ceti	2 34	90 8 47·24	9	46·52	13	47·32	19	+0·72	−0·08
γ Ceti	2 38	87 13 41·54	8	41·35	13	41·84	14	+0·19	−0·30
α Ceti	2 57	86 20 32·36	18	32·28	10	32·15	21	+0·08	+0·21
δ Arietis	3 5	70 41 23·64	9	23·58	19	23·19	24	+0·06	+0·45
α Persei	3 16	40 30 51·50	36	51·41	3	51·92	20	+0·09	−0·42
o Tauri	3 19	81 21 31·41	10	31·88	11	31·75	22	−0·47	−0·34
f Tauri	3 25	77 26 27·26	8	27·02	21	27·16	21	+0·24	+0·10
ϵ Eridani	3 28	98 49 51·98	10	51·35	7	52·33	20	+0·63	−0·35
δ Eridani	3 38	100 8 10·58	10	10·81	8	11·10	15	−0·23	−0·52
η Tauri	3 41	66 14 8·12	10	8·23	14	8·46	33	−0·11	−0·34
γ Eridani	3 53	103 49 19·33	11	18·92	14	19·51	13	+0·41	−0·18
γ Tauri	4 14	74 38 19·39	9	18·96	12	19·04	23	+0·43	+0·35
ϵ Tauri	4 22	71 3 51·41	8	50·71	12	51·76	13	+0·70	−0·35
α Tauri	4 30	73 42 45·07	17	45·00	35	45·07	53	+0·07	0·00
μ Eridani	4 40	93 27 24·87	10	24·82	10	25·13	11	+0·05	−0·26
ι Aurigæ	4 50	57 0 31·87	10	31·35	7	31·51	16	+0·52	+0·36
ϵ Leporis	5 1	112 31 10·29	11	10·04	4	10·28	25	+0·25	+0·01
α Aurigæ	5 9	44 6 52·93	59	53·89	5	53·28	18	−0·96	−0·35
β Orionis	5 9	98 19 45·81	19	44·98	11	45·68	36	+0·83	+0·13
β Tauri	5 19	61 29 10·68	17	9·93	19	10·51	46	+0·75	+0·17
δ Orionis	5 26	90 22 52·89	10	52·42	11	52·40	24	+0·47	+0·49
α Leporis	5 28	107 54 5·72	11	6·08	3	6·47	25	−0·36	−0·75
ϵ Orionis	5 31	91 16 22·40	10	22·19	7	21·74	17	+0·21	+0·66
κ Orionis	5 43	99 42 33·77	10	33·48	7	33·92	16	+0·29	−0·15
α Orionis	5 49	82 36 51·15	17	50·79	26	51·13	43	+0·36	+0·02
β Aurigæ	5 51	45 3 52·42	18	51·44	1	52·66	9	+0·98	−0·24
η Geminorum	6 8	67 27 43·70	10	43·69	4	43·86	17	+0·01	−0·16
μ Geminorum	6 16	67 25 50·73	10	50·43	16	50·61	24	+0·30	+0·12
β Canis Majoris	6 18	107 54 6·62	12	7·32	6	7·02	11	−0·70	−0·40
γ Geminorum	6 31	73 30 27·45	9	26·98	25	27·37	54	+0·47	+0·08
ξ Geminorum	6 39	76 59 11·42	9	11·43	22	11·74	21	−0·01	−0·32

Star's Name.	Approx. R.A.	N.P.D. Pulkowa 1885 reduced to 1890.	No. of Obs.	Secs. of N.P.D. 1890·0 deduced from 1887–1891 Greenwich Five-Year Cat.	No. of Obs.	Secs. of N.P.D. Greenwich Ten-Year Cat., 1880, reduced to 1890.	No. of Obs.	$P-G_V$ $P-G_X$
	h m	° ′ ″		″		″		″ ″
α Canis Majoris	6 40	106 33 56·63	35	59·22	7	58·42	43	(−2·59)(−1·79)
Cephei 51	6 49	2 46 54·66	53	54·72	265	54·96	595	−0·06 −0·30
ζ Geminorum	6 58	69 16 8·68	10	8·48	14	8·62	39	+0·20 +0·06
δ Geminorum	7 14	67 48 57·10	10	57·21	10	57·01	45	−0·11 +0·09
β Canis Minoris	7 21	81 29 22·86	10	23·01	14	22·90	25	−0·15 −0·04
α^2 Geminorum	7 28	57 52 15·45	20	15·36	24	15·33	67	+0·09 +0·12
α Canis Minoris	7 34	84 29 37·47	18	36·22	22	36·35	71	(+1·25)(+1·12)
β Geminorum	7 39	61 42 31·87	18	31·91	18	31·56	78	−0·04 +0·31
ρ Argus	8 3	113 59 15·77	11	16·06	7	15·72	15	−0·29 +0·05
β Cancri	8 11	80 28 33·67	10	33·93	15	33·84	18	−0·26 −0·17
ϵ Hydræ	8 41	83 10 41·14	10	41·16	2	41·16	16	−0·02 −0·02
ι Ursæ Majoris	8 52	41 31 37·29	19	37·66	4	37·07	6	−0·37 +0·22
α Cancri	8 52	77 43 0·64	9	1·36	10	1·09	28	−0·72 −0·45
α Hydræ	9 22	98 10 54·91	17	55·73	11	56·01	30	−0·82 −1·10
o Leonis	9 35	79 36 27·43	11	27·50	14	27·63	28	−0·07 −0·20
ϵ Leonis	9 40	65 43 10·76	11	10·67	8	10·71	27	+0·09 +0·05
μ Leonis	9 47	63 28 31·40	10	31·13	29	31·25	39	+0·27 +0·15
α Leonis	10 3	77 29 43·69	17	43·56	29	44·09	81	+0·13 −0·40
γ^1 Leonis	10 14	69 36 8·58	9	8·61	15	8·80	50	−0·03 −0·22
μ Hydræ	10 21	106 16 30·08	12	30·62	8	30·29	21	−0·54 −0·21
ρ Leonis	10 27	80 7 39·64	10	39·45	9	39·41	29	+0·19 +0·23
α Ursæ Majoris	10 57	27 39 19·18	46	19·67	10	19·40	101	−0·49 −0·22
δ Leonis	11 8	68 52 25·59	14	25·38	21	25·44	64	+0·21 +0·15
δ Crateris	11 14	104 10 59·54	11	60·14	9	60·44	21	−0·60 −0·90
λ Draconis	11 25	20 3 42·72	22	43·12	17	42·95	60	−0·40 −0·23
υ Leonis	11 31	90 12 59·66	11	59·40	12	59·52	47	+0·26 +0·14
β Leonis	11 43	74 48 47·39	18	47·29	24	47·40	52	+0·10 −0·01
β Virginis	11 45	87 36 55·66	16	55·69	10	55·63	32	−0·03 +0·03
γ Ursæ Majoris	11 48	35 41 37·08	33	37·28	7	37·10	35	−0·20 −0·02
o Virginis	12 0	80 39 22·15	10	22·41	18	21·97	22	−0·26 +0·18
ϵ Corvi	12 4	112 0 29·14	10	29·49	6	29·08	20	−0·35 +0·06
η Virginis	12 14	90 3 19·62	11	19·63	10	19·54	33	−0·01 +0·08
δ Corvi	12 24	105 54 10·64	12	11·14	19	11·01	27	−0·50 −0·37
β Corvi	12 29	112 47 18·65	10	18·20	8	18·81	15	+0·45 −0·16
γ^2 Virginis	12 36	90 50 48·33	10	48·91	4	48·52	14	−0·58 −0·19

Star's Name.	Approx. R.A.	N.P.D. Pulkowa 1885 reduced to 1890.	No. of Obs.	Secs. of N.P.D. 1890·0 deduced from 1887–1891 Greenwich Five-Year Cat.	No. of Obs.	Secs. of N.P.D. Greenwich Ten-Year Cat., 1880, reduced to 1890.	No. of Obs.	P−G$_V$	P−G$_X$
	h m	° ′ ″		″		″		″	″
δ Virginis	12 50	86 0 17·06	9	16·83	21	17·01	19	+0·23	+0·05
α Canum Ven.	12 51	51 5 15·07	11	14·91	6	15·04	40	+0·16	+0·03
ε Virginis	12 57	78 26 58·41	10	58·24	9	58·50	52	+0·17	−0·09
α Virginis	13 19	100 35 13·12	105	13·42	19	13·42	86	−0·30	−0·30
ζ Virginis	13 29	90 1 60·07	8	59·87	30	59·63	36	+0·20	+0·44
τ Bootis	13 42	71 59 41·62	8	41·49	17	41·47	21	+0·13	+0·15
η Ursæ Majoris	13 43	40 8 15·11	59	15·61	2	15·30	42	−0·50	−0·19
η Bootis	13 49	71 3 2·69	10	2·71	33	2·28	59	−0·02	+0·41
τ Virginis	13 56	87 55 22·57	8	22·29	18	22·39	33	+0·28	+0·18
α Draconis	14 1	25 5 53·93	20	53·85	23	53·82	77	+0·08	+0·11
κ Virginis	14 7	99 45 41·31	10	41·32	26	41·14	34	−0·01	+0·17
α Bootis	14 11	70 14 40·89	114	40·83	62	40·80	184	+0·06	+0·09
ρ Bootis	14 27	59 8 44·13	10	43·82	9	43·67	27	+0·31	+0·46
ε Bootis	14 40	62 27 42·61	8	42·30	19	42·40	71	+0·31	+0·21
α^2 Libræ	14 45	105 35 3·02	17	3·88	15	3·79	47	−0·86	−0·77
β Ursæ Minoris	14 51	15 23 41·91	32	41·68	21	41·66	98	+0·23	+0·25
β Bootis	14 58	49 10 31·22	8	31·81	4	30·50	9	−0·59	+0·72
β Libræ	15 11	98 58 35·74	10	36·29	6	36·10	22	−0·55	−0·36
α Coronæ	15 30	62 54 53·64	16	53·05	38	53·79	71	+0·59	−0·15
α Serpentis	15 39	83 13 40·70	16	40·63	35	40·54	29	+0·07	+0·16
ε Serpentis	15 45	85 11 27·36	9	26·79	22	26·71	25	+0·57	+0·65
ζ Ursæ Minoris	15 48	11 52 3·07	16	2·50	19	2·60	28	+0·57	+0·47
γ Serpentis	15 51	73 58 44·56	9	44·24	15	44·79	14	+0·32	−0·23
β Scorpii	15 59	109 30 13·25	9	13·64	16	13·88	26	−0·39	−0·63
δ Ophiuchi	16 9	93 24 38·38	10	38·49	24	38·26	37	−0·11	+0·12
γ Herculis	16 17	70 35 17·93	9	17·58	12	17·37	41	+0·35	+0·56
η Draconis	16 23	28 14 12·76	26	12·09	5	12·31	45	+0·67	+0·45
Antares	16 23	116 11 13·83	8	15·09	9	14·14	32	−1·26	−0·31
λ Ophiuchi	16 25	87 46 29·42	10	29·18	10	29·63	21	+0·24	−0·21
ζ Ophiuchi	16 31	100 21 37·60	10	37·55	23	37·66	23	+0·05	−0·06
ζ Herculis	16 37	58 11 51·81	9	52·10	16	51·36	56	−0·29	+0·45
κ Ophiuchi	16 52	80 27 13·05	9	12·98	24	13·23	44	+0·07	−0·18
ε Herculis	16 56	58 54 40·98	9	40·44	11	40·58	38	+0·54	+0·40
ε Ursæ Minoris	16 57	7 46 57·68	17	57·42	25	57·99	21	+0·26	−0·31
η Ophiuchi	17 4	105 35 17·06	9	17·34	33	17·40	24	−0·28	−0·34
α Herculis	17 10	75 29 2·31	16	1·86	29	2·10	38	+0·45	+0·21

Star's Name.	Approx. R.A.	N.P.D. Pulkowa 1885 reduced to 1890	No. of Obs.	Secs. of N.P.D. 1890·0 deduced from 1887–1891 Greenwich Five-year Cat.	No. of Obs.	Secs. of N.P.D. Greenwich Ten-Year Cat., 1880, reduced to 1890.	No. of Obs.	P−G$_V$	P−G$_X$
	h m	° ′ ″		″		″		″	″
β Draconis	17 28	37 37 1·38	19	1·39	9	1·17	25	−0·01	+0·21
α Ophiuchi	17 29	77 21 34·22	16	34·10	65	34·40	79	+0·12	−0·18
β Ophiuchi	17 38	85 23 10·86	10	10·37	42	10·89	45	+0·49	−0·03
μ Herculis	17 42	62 12 52·97	8	52·58	21	52·63	49	+0·39	+0·34
γ Draconis	17 54	38 29 52·97	36	52·68	13	52·49	46	+0·29	+0·48
72 Ophiuchi	18 2	80 27 5·23	10	5·00	27	5·30	37	+0·23	−0·07
μ Sagittarii	18 7	111 5 12·42	11	13·59	11	13·53	19	−1·17	−1·11
δ Ursæ Minoris	18 8	3 23 18·27	55	18 05	232	18·46	589	+0·22	−0·19
η Serpentis	18 16	92 55 37·18	11	36·98	30	36·77	38	+0·20	+0·41
α Lyræ	18 33	51 19 6·44	17	6·44	76	6·40	217	0·00	+0·04
β Lyræ	18 46	56 45 53·10	8	53·13	11	52·71	33	−0·03	+0·39
ε Aquilæ	18 55	75 4 50·71	8	51·02	24	50·49	58	−0·31	+0·22
ζ Aquilæ	19 0	76 17 58·96	10	58·76	48	59·10	73	+0·20	−0·14
δ Aquilæ	19 20	87 6 15·15	9	14·87	34	14·64	36	+0·28	+0·51
λ Ursæ Minoris	19 34	1 1 59·61	27	59·19	227	59·37	489	+0·42	+0·24
γ Aquilæ	19 41	79 39 16·14	16	16·31	10	16·42	24	−0·17	−0·28
α Aquilæ	19 45	81 25 18·47	17	19·12	30	19·04	59	−0·65	−0·57
β Aquilæ	19 50	83 52 3·60	16	3·32	13	3·08	28	+0·28	+0·52
θ Aquilæ	20 6	91 8 50·46	10	50·35	33	50·20	52	+0·11	+0·26
α^2 Capricorni	20 12	102 53 7·19	16	8·04	13	7·41	19	−0·85	−0·22
β Capricorni	20 15	105 7 41·88	10	41·43	9	42·45	33	+0·45	−0·57
ρ Capricorni	20 23	108 10 36·91	10	37·11	6	36·79	23	−0·20	+0·12
ε Delphini	20 28	79 4 13·15	8	13·43	23	13·66	23	−0·28	−0·51
α Delphini	20 35	74 28 32·81	9	32·55	5	33·04	25	+0·26	−0·23
α Cygni	20 38	45 6 45·19	39	45·03	3	45·65	27	+0·16	−0·46
ε Aquarii	20 42	99 53 52·99	11	53·49	13	53·30	26	−0·50	−0·31
61 Cygni	21 2	51 47 28·94	10	29·18	4	29·23	15	−0·24	−0·29
ζ Cygni	21 8	60 13 26·93	8	26·58	27	26·84	51	+0·35	+0·09
α Equulei	21 10	85 12 24·31	8	23·80	9	24·15	18	+0·51	+0·16
α Cephei	21 16	27 52 49·36	49	49·25	24	49·92	77	+0·11	−0·56
β Aquarii	21 26	96 3 17·66	10	17·74	15	17·51	36	−0·08	+0·15
β Cephei	21 27	19 55 19·52	36	19·49	12	20·10	74	+0·03	−0·58
ε Pegasi	21 39	80 37 44·93	9	45·18	21	45·21	37	−0·25	−0·28
δ Capricorni	21 41	106 37 34·15	12	34·82	9	34·26	10	−0·67	−0·11
α Aquarii	22 0	90 51 14·51	18	14·45	24	14·29	34	+0·06	+0·22

Star's Name.	Approx. R.A.	N.P.D. Pulkowa 1885 reduced to 1890.	No. of Obs.	Secs. of N.P.D. 1890·0 deduced from 1887–1891 Greenwich Five-Year Cat.	No. of Obs.	Secs. of N.P.D. Greenwich Ten-Year Cat. 1880, reduced to 1890.	No. of Obs.	P−G$_V$	P−G$_X$
	h m	° ′ ″		″		″		″	″
ι Pegasi	22 2	65 11 31·32	8	30·56	13	31·76	33	+0·76	−0·44
γ Aquarii	22 16	91 56 29·51	10	29·10	16	29·25	13	+0·41	+0·26
η Aquarii	22 30	90 41 3·88	10	3·57	20	3·56	15	+0·31	+0·32
ζ Pegasi	22 36	79 44 34·29	9	34·12	25	34·52	15	+0·17	−0·23
μ Pegasi	22 45	65 58 45·06	8	44·61	13	45·30	41	+0·45	−0·24
λ Aquarii	22 47	98 9 53·50	10	53·96	14	53·62	42	−0·46	−0·12
α Pegasi	22 59	75 23 11·85	16	11·47	14	11·83	30	+0·38	+0·02
γ Piscium	23 11	87 19 7·89	9	7·73	14	7·62	44	+0·16	+0·27
ι Piscium	23 34	84 58 12·19	8	12·04	14	11·90	27	+0·15	+0·29
γ Cephei	23 35	12 58 53·54	19	52·80	24	53·69	68	+0·74	−0·15
ω Piscium	23 54	83 44 44·98	9	44·42	24	44·83	38	+0·56	+0·15

In those cases where there are fewer than 10 observations in the Greenwich Five-Year Catalogue, the mean N.P.D. 1890·0 deduced from the observations 1887–1891, has been used instead of the adopted Catalogue place, which was found by a combination of the observations in 1887–1891 with the Ten-Year Catalogue.

The weights adopted for combining the results are from the formula

$$\frac{4\,mn}{m+n+\frac{1}{5}\,mn},$$

where m and n are the number of observations of any star in any two of the catalogues. The results given by *Sirius* and *Procyon* have not been used. The general apparent mean correction to the Greenwich Ten-Year Catalogue is $-0''\cdot04$, and to the Five-Year Catalogue $+0''\cdot06$, or to the mean of the two, practically zero.

The following are the differences arranged in order of time for every six hours of right ascension, and corrected for the general mean.

	0^h − 6^h	6^h − 12^h	12^h − 18^h	18^h − 24^h
	″	″	″	″
P−G$_X$	+0·01	−0·07	+0·09	−0·04
P−G$_V$	+0·13	−0·17	+0·01	−0·03
P−½ (G$_X$+G$_V$)	+0·07	−0·12	+0·05	−0·04

Arranging them again for every 10° of N.P.D., the mean N.P.D. and difference become

N P.D.	3°	15°	26°	36½°	44°	55½°	65°	75°	84°	94½°	104½°	113°
P − G_V	+″·20$_5$	+″·40$_4$	+″·05$_6$	−″·15$_4$	−″·19$_8$	+″·12$_{11}$	+″·30$_{21}$	+″·14$_{28}$	+″·09$_{29}$	+″·07$_{25}$	−″·33$_{18}$	−″·44$_5$
P − G_X	−·09	−·02	−·17	+·04	−·07	+·22	+·03	−·03	+·03	+·03	−·37	−·24
P − ½ (G_X + G_V)	+·06	+·19	−·06	−·05	−·13	+·17	+·16	+·06	+·06	+·05	−·35	−·34

The subscribed numbers denote the numbers of stars on which the results depend, and which are the same in every case.

The places of stars whose N.P.D.'s lies between 0° and 41° depend on below pole as well as above pole observations.

The results are more accordant than might have been expected from the small number of stars on which some of the quantities depend, and indicate that the system of reductions and the constants in use at the two observatories give practically identical results. The tendency to run off at the end is not in favour of M. Nyrén's proposed diminution of the adopted Pulkowa refractions.

Indirectly we get the following comparison between the Greenwich Ten-Year, 1880, and Five-Year, 1890, Catalogues.

G_V − G_X	+″·29	+″·42	+″·22	−″·19	−″·12	−″·10	+″·27	+″·17	+″·06	+″·04	+″·04	−″·22

For a comparison between the refractions of Bessel's tables and those of Pulkowa, reference should be made to Professor Simon Newcomb's paper on the Greenwich North Polar Distances, in vol. ii. pp. 418–424 of the Astronomical Papers prepared for the use of *The American Ephemeris and Nautical Almanac*.

Royal Observatory, Greenwich:
1894 *November* 6.

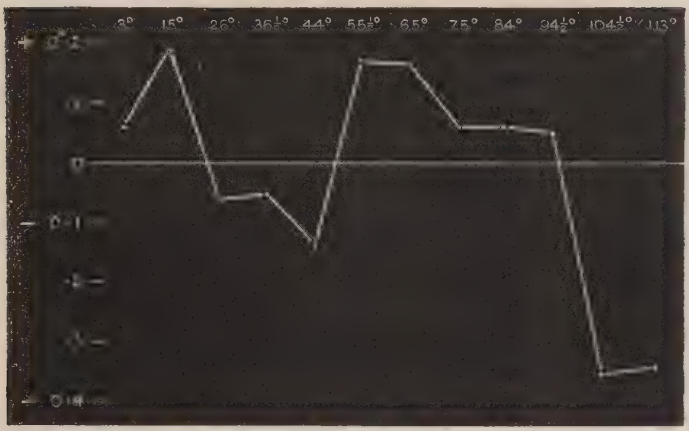


Diagram showing the apparent discordances in North Polar Distances between the Mean of the Greenwich Ten-Year (1880) and Five-Year (1890) Catalogues, and the Pulkowa Catalogue 1885, reduced to 1890.

Note on the Latitude of the Royal Observatory, Cape of Good Hope. By David Gill, LL.D., F.R.S., Her Majesty's Astronomer at the Cape.

In the introduction to the Cape Catalogue for 1885, recently printed, there is given a discussion of the systematic errors of the Declinations of the Greenwich Ten-Year Catalogue and the Cape General Catalogue for 1885.

The results of that discussion show that if the co-latitudes are

$$\text{For Greenwich } 38^\circ\ 3'\ 21''\cdot90 + X,$$
$$\text{„ Cape } \quad 123\ 56\ 3\cdot35 + x;$$

then

$$X = -0''\cdot103; \qquad x = +0''\cdot186.$$

Further, the refractions of the *Tabulæ Regiomontanæ* require to be multiplied by the following factors :—

At Greenwich by $(1 - 0\cdot00217)$
„ the Cape by $(1 - 0\cdot00218)$
} The zenith distances being limited to 80°.

The general accuracy of these interdependent results has been remarkably confirmed as follows :—

As an independent control on the system of declinations, a number of pairs of stars was selected for observation with the zenith telescope, and some years ago a list of these pairs of stars was forwarded to Dr. Otto Struve (then Director of the Pulkowa Observatory), with a request that the northern stars of the list should be observed at Pulkowa, either by referring them to the Pulkowa fundamental stars with the transit circle, or observing them fundamentally with the vertical circle.

Dr. Struve expressed the opinion that for such work he considered the vertical circle should be employed; that Dr. Nyrén was unable to undertake observations of the complete list with the vertical circle, but had promised to observe a list of twenty-two stars of special importance, and he hoped that Dr. Romberg would be able to observe the others with the transit circle.*

These twenty-two northern stars were selected in such a way that for each of eleven southern circumpolars there should be one northern star forming a Talcott-latitude pair with it at upper culmination, and another at lower culmination. The twenty-two

* I am since informed that Dr. Romberg has observed these stars with the transit circle, but the results have not yet reached me.

Talcott pairs thus formed were observed with the zenith telescope at the Cape, and the twenty-two northern stars were observed by Dr. Nyrén with the vertical circle at Pulkowa. The results of Dr. Nyrén's observations were kindly communicated by him on 1889 March 9, and are also published in the *Astronomische Nachrichten*, No. 2904.

In the mean of two latitude pairs, in one of which the south component is a circumpolar star at upper transit, and in the other pair the southern star is the same circumpolar at lower transit, it is clear that the mean declination of the south stars (apart from change of latitude between the epochs of observation of the two pairs) must be rigorously $= 90°$. The deduced latitude from pairs thus combined will therefore rest entirely on the Pulkowa declinations, and be independent of errors in the assumed places of the southern circumpolars.

The results are based on four observations of each northern star at Pulkowa, and on ten to twelve observations of each pair with the zenith telescope at the Cape.

The Cape observations extend from 1886 to 1891, and the effect of change of latitude is practically eliminated, as is shown by the results with and without Chandler's corrections for change of latitude.

With the places of the northern stars given in the *Ast. Nach.*, No. 2904, the reduction of the observations gives (Introduction to Cape Catalogue for 1885·0, pp. xlvi, xlvii)

Latitude of the Cape transit circle...	$-33^\circ\ 56'\ 3''.65$
The latitude derived from the discussion of the Cape and Greenwich transit-circle observations being	3·54
Difference	0·11

But within the past few days the Pulkowa Observations, Series II. vol. i., has reached the Cape. In the list of stars occasionally observed Dr. Nyrén there gives the finally discussed positions of the twenty-two northern stars. Employing these corrected positions in lieu of those published in the *Ast. Nach.*, No. 2904, the latitude of the Cape comes out

	$-33^\circ\ 56'\ 3''.57$
Or, as above, from the meridian observations	3·54
Difference	0·03

This remarkable agreement between results arrived at by methods, instruments, and observers so entirely distinct from each other cannot but be regarded as extremely satisfactory. The separate results are given below :—

South Star.	North Star.	Excess of North Z.D. 1887·0.	Resulting Latitude. Without Chandler's Corrections.	With Chandler's Corrections.
		″	° ′ ″	″
Brisb. 4091 S. P.	Pulk. (1855) 115	+229·04	−33 56 3·50	3·49
Brisb. 4091	Pulk. (1855) 1829	−501·03		
Stone 7461 S. P.	W_2 1^h 758–60	+345·30	3·27	3·25
Stone 7461	Pulk. (1855) 1927	+517·07		
Lac. 1848	Pulk. (1855) 475	− 50·76	3·49	3·50
Lac. 1848 S. P.	Pulk. (1855) 2202	−383·19		
Stone 9273 S. P.	Arm.$_2$ 573	+503·25	3·55	3·53
Stone 9273	Pulk. (1855) 2483	−254·21		
Lac. 1839	Pulk. (1855) 732	−307·52	3·93	3·93
Lac. 1839 S. P.	Pulk. (1855) 2417	− 9·06		
Stone 2901	Pulk. (1855) 1052	+264·89	3·64	3·62
Stone 2901 S. P.	Pulk. (1855) 2603	+ 67·07		
σ Octantis S. P.	Pulk. (1855) 1148	−201·22	3·73	3·74
σ Octantis	Pulk. (1855) 2706	+423·58		
A Octantis	Pulk. (1855) 1196	−492·94	3·40	3·38
A Octantis S. P.	Lalande 37406–7	− 48·63		
τ Octantis S. P.	Arm.$_2$ 1259	− 91·51	3·51	3·50
τ Octantis	Arm.$_2$ 3116	+279·08		
Lac. 4578	W_2 10^h·1118	−313·33	3·65	3·62
Lac. 4578 S. P.	Arm.$_2$ 3084	−127·62		
Stone 6404	Pulk. (1855) 1719	+118·21	3·75	3·72
Stone 6404 S. P.	Pulk. (1855) 3403	− 80·61		
	Means...		−33 56 3·58	3·57
	Probable Error		±0·04	±0·04

Royal Observatory, Cape of Good Hope:
1894 October 16.

Preliminary Note on the Position of the Liverpool Observatory.

By W. E. Plummer, M.A.

In the Annual Report of the Council for the year 1867 it is stated : "From five transits of β *Draconis*, four of γ *Draconis*, and one of α *Cygni*, each of them over the east and west prime verticals, the latitude (of the Liverpool Observatory) is 53° 24′ 3″·8 N." As far as I know, no details have ever been published, nor can I find in the archives of the Observatory any record of the observations.

It was with the view of confirming this result, and also to test how far the instrument was available for the accurate determination of latitude, that the following observations were undertaken.

The Observatory is not equipped with a transit circle, but a third pier has been erected to the north of the eastern pier at right angles to the meridian, and at such a distance as to permit the transit instrument being placed between this and the eastern pier. The Y bearings and the mounting generally are in all respects similar to those employed when the instrument is on the meridian. The new position of the line of collimation is 1 foot 8 inches north of the ordinary transit.

The means for reversal of the instrument are not convenient, and the operation cannot be effected under about three minutes, so that it is only for stars which cross within a few minutes of the zenith that it is possible to reverse the telescope during the transit. Practically the instrument has only been reversed for the determination of collimation, and the whole of the transit has usually been made in either the north or the south position. Neither could the telescope be used as a zenith instrument in the ordinary Talcott or Horrebow method. For these reasons it has been necessary to rely on pairs of observations of the same stars made on different nights in reversed positions of the axis.

It was originally intended to bisect the star when near the prime vertical by the micrometer wire, noting the time ; but this method had to be abandoned, not only because the micrometer was in a very inconvenient position for reading when the telescope was nearly vertical, but the earlier observations so made showed that there was some loss or irregularity in the screw which it was impossible to make entirely disappear. These observations have accordingly all been rejected, and those observations only have been retained which depend upon transits over the fixed wires of the instrument.

These are nine in number, and under the most favourable circumstances could only give four contacts in each reversed position of the instrument—another reason for not reversing during each transit. The intervals between these wires, when de-

termined by means of the movable thread being brought into coincidence with each, exhibited the same uncertainty as that already noticed, and furnished additional grounds for the rejection of the earlier observations.

The wire intervals used depend entirely upon the meridional transits of polar stars, and are, I believe, perfectly trustworthy. The derivation of the intervals from the prime vertical observations themselves shows a satisfactory accord with those used.

The level corrections have always been small and consistent, and the practice has been to determine the level error at least three times in the course of the observations, practically about once an hour. There has been noticed an occasional tendency for the northern pier to sink (or the southern pier to rise) as the night wore on. The maximum effect has been to alter the level about 1″ in the course of the evening. The probable error of a single determination, however, is as much as 0″·2. It does not seem possible to connect this gradual change with temperature, since it is not always present, nor when the greatest range of temperature has been noticed. The value of the level scale 0″·90 is that which has been in use for some years. I have no adequate means of making a fresh determination. Practically, if ΔL be the correction to the level scale, the final latitude would have to be increased by 1·35 ΔL. An examination of the level errors as applied to separate values of the latitude in north and south positions of the instrument has not, however, shown the necessity of any correction.

The azimuth has remained small and constant throughout the observations. Sometimes stars at a considerable distance from the zenith have been observed, but it has been found sufficient to determine the hour angle of the meridian of the instrument from the zenith stars themselves. The correction $\frac{1}{2}\, a^2 \sin 1'' \cot \phi$ has never been sensible.

The transits have been made by the chronographic method. For slow-moving stars the method is probably inferior to eye and ear transits, but owing to the relative situation of the piers and the clock, the latter could not be seen when observing, and one was liable to errors in counting. The clock error and rates were so completely under control, that any error caused by their variation is of a smaller order than the error of observation.

Since there was no object in observing very close to the zenith, either with the view of reversing the telescope during the transit or from fear of irregularity in the performance of the clock, the choice of the selected stars depended upon the accuracy with which the transits could be made, and the effect of this error upon the latitude. If ϵ be the probable error in the time of transit, and t half the interval of time between E. and W. vertical circles, then the effect on the latitude ϕ is

$$d\phi = \frac{\epsilon}{2} \sin 2\phi \tan t.$$

It was found that the probable error of observation was sensibly the same for all transits in which t exceeded 20°, and that, practically, the increase in the error of observation when t was less than 7° increased the error of the latitude. The minimum effect on the latitude was produced when t was about one hour or when $(\phi - \delta)$ was about one degree. As the effect of an error in the assumed declination of the star on the resulting latitude is expressed by

$$d\phi = d\delta \frac{\sin 2\phi}{\sin 2\delta},$$

possibly a slight increase in the accuracy might have resulted by making $\phi - \delta$ a larger angle; but this slight gain is more than compensated by the longer interval in the transit and the greater danger of losing the second by clouds.

On these considerations the following list of stars, arranged in order of $(\phi - \delta)$, was drawn up from the most authentic sources attainable. The declinations have been reduced as far as possible to the A. G. C. system, and the proper motions have in general been taken from the discussion of proper motion, vol. xxv. of the *Annals of the Harvard Observatory*. In a few cases the proper motion has been independently determined. The programme provided for observing each star five times in both north and south positions, and this rule has been very generally adhered to. The stars *c*, *f*, *l*, and *m* have, however, only been observed four times, the west transit being lost from clouds. An increase in the number of observations did not sensibly increase the accuracy of the result derived from each individual star, and of course the error in the assumed declination remained practically unremoved. It seemed more advantageous to increase the number of the stars than to multiply observations of the same star.

Letter of Reference.	Star's Name.	Assumed Declination. 1894·0.	Assumed Proper Motion.	Approximate Right Ascension. 1894·0.	Authority.
		° ′ ″	″	h m s	
a	51 Draconis	53 14 2·25	+0·027	19 2 33·2	Gr. 80, Pulk. 55, Harv. 75.
b	κ Cygni	53 10 22·31	+ ·112	19 14 39·2	Berliner Jahrbuch 1894.
c	Groomb. 3403	53 7 49 74	+ ·006	21 6 58·9	Gr. 72, Pulk. 55, Gl. 70, Harv. 75.
d	Groomb. 2671	52 52 16·02	− ·034	18 44 25·2	Gr. 80, Rad. 45, Gr. 60, Harv. 75.
e	Groomb. 3383	52 51 49·21	·000	21 0 33·3	Gr. 80, Rad. 45, Wash. 60, Harv. 75.
f	Groomb. 3042	52 51 8·37	+ ·253	20 3 26·5	Gr. 72, Pulk. 55, Rad. 45, Harv. 75.
g	Groomb. 2699	52 50 20 14	+ ·352	18 49 12·7	Gr. 64, Pulk. 55, Wash. 60, Harv. 75.
h	Groomb. 3100	52 47 52·83	+ ·163	20 10 51·8	Rad. 45, Brus. 65, Harv. 75.
i	Groomb. 3690	52 47 21·76	− ·013	22 3 30·1	Wash. 60, Rad. 45, Harv. 75.
j	Groomb. 3617	52 44 24·58	·000	21 51 47·6	Gl. 70, Brus. 65, Rad. 45, Harv. 75.
k	20 Cygni	52 43 8·01	− ·132	19 47 58·1	Gr. 80, Pulk. 55, Rad. 45, Harv. 75.
l	Groomb. 3285	52 36 34·67	− ·100	20 43 16·9	Gl. 70, Brus. 65, Rad. 45, Harv. 75.
m	Groomb. 3434	52 36 33·75	− ·033	21 16 16·2	Rad. 45, Harv. 75.
n	Groomb. 3436	52 31 39·41	+ ·052	21 16 33 9	Rad. 45, Harv. 75 (double).
o	Groomb. 3480	52 29 29·33	+ ·031	21 26 48·6	Gr. 80, Pulk. 55, Rad. 45, Harv. 75.
p	Groomb. 3467	52 26 16·83	·000	21 23 15·3	Gr. 80, Rad. 60, 45, Brus. 65, Harv. 75
q	ψ Cygni	52 9 26·75	− ·046	19 52 53 4	Berliner Jahrbuch, 1894.
r	Groomb. 2753	52 6 27·15	− ·010	18 59 37·5	Rad. 45, Harv. 75.
s	ι Cygni	52 6 15·87	− ·060	19 24 50·3	Gr. 72, Gr. 60, Rad. 45, Harv. 75.
t	Groomb. 3213	51 56 54·70	+ ·063	20 28 19·5	Rad. 45, Bonn 55, Harv. 75.
u	Lalande 40328	51 31 1·79	·000	20 45 30·8	Gr. 80, Brus. 65, Harv. 75.
v	Groomb. 3239	51 29 19·09	+ ·014	20 31 45·2	Gl. 70, Brus. 65, Rad. 45, Harv. 75.

As an example of the agreement in the individual results determined from each of the two positions of the telescope, as well as to exhibit the constancy of the errors of the instrument, the latitude derived from the separate nights' observations of one star, the first in the list, is given. The collimation error has been determined both by reversion and by reflection. The level errors where a gradual change has been noticed as the night advanced have been varied with the time, the quantity shown in column 5 being that actually used; the azimuthal error has never been sufficiently large to be applied. In the final values for the latitude there remains only the correction due to the employment of inaccurate values in the intervals of the wires, and this is effectually masked by the errors of the observations themselves.

Date.	Position of Lamp.	$\phi' - \delta_a$	Error of Collimation Lamp N.	Inclination.	Azimuthal Error.	Appt. δ.	Latitude.
1894.		′ ″	″	″	″	° ′ ″	° ′ ″
Sept. 5	N.	9 48·24	+1·74	+2·62	−3·12	53 14 13·96	53 24 4·82
6	S.	9 48·08	+2·03	+2·05	−3·05	14·12	4·25
10	S.	9 48·97	+2·30	+0·41	−1·92	14·75	4·13
13	N.	9 49·18	+1·60	+0·73	−1·47	15·15	5·06
14	S.	9 48·68	+·42	+1·25	−0·73	15·28	5·20
24	N.	9 45·32	+·27	+3·02	−1·25	16·31	4·65
27	N.	9 43·94	−·35	+3·87	−0·96	16·51	4·32
29	S.	9 48·40	+·11	+0·26	−2·42	16·63	5·29
Oct. 1	S.	9 46·95	−·86	+1·62	−3·80	16·73	5·30
2	N.	9 47·77	−1·03	+0·83	−1·35	16·76	5·26

The mean results from each of the stars are as follows :—

Star.	Mean Latitude.	Average Deviation.	Star.	Mean Latitude.	Average Deviation.
	° ′ ″	″		° ′ ″	″
a	53 24 4·83	0·40	*l*	53 24 5·63	0·39
b	5·25	0·53	*m*	5·22	0·56
c	5·04	0·36	*n*	4·39	0·75
d	4·27	0·62	*o*	4·70	0·32
e	4·64	0·44	*p*	4·28	0·41
f	4·32	0·53	*q*	5·44	0·38
g	4·98	0·39	*r*	5·04	0·83
h	5·45	0·70	*s*	4·31	0·36
i	5·21	0·63	*t*	5·29	0·42
j	3·97	0·75	*u*	4·70	0·55
k	4·26	0·58	*v*	5·04	0·70

The average deviation of each determination from the mean is given, from which the probable errors could easily be derived; but the uncertainty in the assumed declination of the star remains, though it is hoped that to some extent its influence on the final result is removed by employing a considerable number of stars. In presence of this uncertainty, however, it does not seem desirable to adopt any more elaborate method of deducing the mean result than to take the arithmetic mean, and this gives for the latitude of the Liverpool Observatory 1894·7

53° 24′ 4″·84.

An examination of the residuals discloses the unwelcome fact that they are rather large, and that the further prosecution of the subject with the present instrument is not likely to be of any scientific value as a contribution to the question of the variation of the latitude.

Longitude.

The information concerning the longitude determination is as vague as that of the latitude. In the Report of the Council, 1868, already quoted, it is stated that the difference of longitude between the old and the new observatory was "found by the transmission of sixty chronometers to be $17^{s}\cdot04$." The longitude of the old observatory was determined by the late Astronomer Royal in the course of the Valentia inquiry (1844), and is quoted for several years in the *Nautical Almanac* as $12^{m}\ 0^{s}\cdot11$ W.

So far as can be gathered from the records, these sixty chronometers were simply carried from one observatory to the other in the ordinary course of removal, no repetition of the journey being made. Consequently any error in the original determination of clock error impressed itself on the result. Circumstances pointed to the fact that these errors might be considerable, both in the last clock error in the old observatory, and in the first in the new. Further, the longitude of the old observatory rested entirely on the results of the chronometrical expedition in 1844, and might very well be repeated by the method of galvanic signals. It is true that the 1862 determination of the Feagh Main Station by this process agreed very closely with the older result, so that no considerable alteration in the assumed longitude of the new observatory could be anticipated, but the connecting link between the two seemed sufficiently weak to make a fresh inquiry desirable.

The method employed was the exchange of signals recorded on the respective chronographs of the two observatories, the clock errors being determined at each observatory in the ordinary course of observation. The hour chosen for the exchange of signals was 9 P.M., a time when, weather permitting, observations were usually going on, and any uncertainty in the clock rate was practically avoided. The clock employed here was the Bond clock, mentioned in the Report of the Council, 1868. It has

always given me most trustworthy results. The Astronomer Royal has kindly furnished me with the clock errors and rates of the sidereal standard employed at Greenwich.

With regard to the Liverpool observations, it may be mentioned that the collimation error has been determined both by observations of the reflected wire and by transits of polar stars in reversed positions of the intrument. The agreement between the two methods is not very satisfactory, though the difference is by no means systematic. The want of stability in the screw mentioned in the case of the latitude observations is the probable cause of the disagreement, and, as a matter of fact, the collimation error rests entirely on the observation of polar stars. The variation of the error from night to night is very small, and it is believed that the error itself is accurately known. The level error has been found by means of a striding level, and the remarks on the determination of its scale referred to in the earlier sections are to be considered here. The results of the prime vertical observations have, on the whole, convinced me of the very approximate accuracy of the scale value. The level error has also been derived from reflection; but here, again, the method has never recommended itself. The azimuthal error has been derived from the observation of the ordinary polar stars, including those whose places are given in the *Connaissance des Temps*. Within the period embraced by the longitude observations, seven stars were used.

Owing to some difficulty in making the proper connections with the Liverpool chronograph, the Greenwich signals failed to register for the first few nights, and not all the signals (thirty from each station) sent from Liverpool were registered at Greenwich. The "relay time" (shown below), however, seems sufficiently well known from the latter part of the inquiry to warrant the application of one-half the mean interval to the earlier observations.

	Relay Time. Mean of 20 Signals.	Relay Time. Mean of 10 Signals.
	s	
Aug. 30	(−0·003) (only 8 recorded)	
		s
Sept. 4	+ ·016	+0·024
5	+ ·020	+0·035
6	+ ·006	+0·038
12	+ ·025	+0·032
13	+ ·017	+0·049
19	+ ·027	+0·022
20	+ ·015	+0·010
26	+ ·024	+0·039
Mean	+ ·019	+0·031

The mean $0^s{\cdot}023$ has been assumed as the correct interval on those days on which the signals were not efficiently exchanged.

Two attempts were made to determine the personal equation of the Liverpool observer, referred to the Greenwich standard. The results are not very satisfactory. Bad weather defeated the earlier attempt, the only result being to show that the personal equation was practically zero. At the second attempt the following, not very accordant results, were obtained :—

Date.	Greenwich—Liverpool (Clock Slow).	Date.	Greenwich—Liverpool (Clock Slow).
	s		s
1894 April 21	+0·33	1894 April 28	0·00
26	−0·10	May 1	+0·14
27	+0·17		

The mean $+0^{s}\cdot11$ has been employed in the derivation of the following values of the longitude from each of the nights on which signals were satisfactorily exchanged :—

		m	s			m	s
1893 Aug. 9	Long. W.	12	17·34	1893 Sept. 6	Long. W.	12	17·27
15			17·24	12			17·33
16			17·24	13			17·42
23			17·36	19			17·39
30			17·30	20			17·34
Sept. 4			17·38	26			17·33
5			17·37				

The mean of these values it is proposed to adopt for the present, and the resulting position of the Liverpool Observatory is—Latitude, N. 53° 24′ 4″·8 ; Longitude, W. $12^{m}\ 17^{s}\cdot33$.

Liverpool Observatory,
1894 *November* 8.

Observations of Comet II. 1894 (*Gale*). By W. E. Plummer, M.A.

The following observations of Gale's Comet have been made with the equatorial of the Liverpool Observatory. When the comet was sufficiently bright to admit of any illumination in the field the observations were made with a filar micrometer. The remainder, marked "Ret.," have been made by a micrometer of thick wires crossed at right angles, and placed at an angle of 45° with the meridian. Five transits have usually been made when this micrometer has been used. All the observations have been corrected for differences of refraction, but no corrections for parallax have been applied. In the column "Observer," the letters "P." and "S." refer to Mr. Plummer and Mr. Skinner, respectively :—

Liverpool Mean Time of Observation.				☄−★ R.A.	No. of Comparisons (α).	Apparent R.A. of ☄.	☄−★ Declination.	No. of Comparisons (δ).	Apparent Declination of ☄.	Log Factor of Parallax in (α).	Log Factor of Parallax in (δ).	Observer.	Star of Reference.
1894.	h	m	s	m s		h m s	′ ″		° ′ ″				
May 4	8	37	2	+8 58·51	13	8 28 17·01	+10 9·7	3	− 3 14 19·6	9·3966	0·8617	P.	*a*
	...			+7 53·97	13	8 28 16·30	+19 25·1	3	− 3 14 16·4	...	...	P.	*b*
7	9	34	11	+ 22·60	16	8 27 59·99	+15 58·5	4	+ 7 29 58 3	9·4629	0·8204	P.	*c*
9	10	2	58	+1 0·02	16	9 15 2·56	+ 1 5·5	4	+13 23 19·5	9·4952	0·7966	P.	*d*
	...			− 29·66	16	9 15 2·64	−10 33·0	4	+13 23 17·4	...	...	P.	*e*
10	9	53	37	− 49·33	12	9 22 44·36	+ 5 17·4	3	+15 55 24·2	9·4846	0·7781	P.	*f*
	10	7	49	− 44·84	12	9 22 48·85	+ 6 44·9	3	+15 56 51·7	9·5013	0·7883	S.	*f*
12	11	13	46	+ 39·21	16	9 37 19·20	+ 1 14·7	4	+20 28 18·3	9·5600	0·7883	P.	*g*
	11	20	47	− 6·26	12	9 37 21·32	−11 47·1	3	+20 28 55·0	9 5634	0·7922	P.	*h*
16	10	35	22	+1 44·19	16	10 1 14·16	+ 4 57 0	4	+27 5 20·7	9·5480	0·7168	P.	*i*
	...			− 37·88	16	10 1 14·52	− 5 52·9	4	+27 5 21·3	...	...	P.	*j*

1894.	Liverpool Mean Time of Observation. h m s	☄−✱ R.A. m s	No. of Comparisons (α).	Apparent R.A. of ☄. h m s	☄−✱ Declination. ′ ″	No. of Comparisons (δ).	Apparent Declination of ☄. ° ′ ″	Log Factor of Parallax in (α).	in (δ).	O' server.	Star of Reference.
May 17	9 38 40	+ 43·51	12	10 6 18·62	− 58·4	3	+28 21 5·5	9·5181	0·5594	P.	*k*
	9 45 52	+ 45·05	12	10 6 20·16	− 35·8	3	+28 21 28·1	9·4898	0·6651	S.	*k*
18	10 26 5	−3 10·80	20	10 11 29·72	+ 6 40·4	5	+29 35 15·7	9·5464	0·6860	P.	*l*
	10 35 55	−3 8·87	20	10 11 31·65	+ 7 11·2	5	+29 35 46·5	9·5566	0·6929	S.	*l*
21	9 45 59	+1 43·28	Ret.	10 25 6·73	+ 1 6·6	Ret.	+32 34 6 4	9·5039	0·6148	P.	*m*
	...	−1 24·22	„	10 25 6 59	+ 3 52·6	„	+32 31 5·9	9 5039	0·6148	P.	*n*
21	9 59 3	+1 45·64	„	10 25 9·09	+ 1 33·8	„	+32 34 33·6	9 5238	0·6278	P.	*m*
	...	−1 21·69	„	10 25 9·12	+ 4 20·0	„	+32 34 33·3	...	...	S.	*n*
24	10 12 30	− 22·58	20	10 37 11·82	− 9 31·9	5	+34 54 30·7	9·6533	0·6151	P.	*o*
	...	+1 7·00	20	10 37 11·94	− 9 37·1	5	+34 54 32·1	...	...	P.	*p*
27	12 2 5	− 49·25	16	10 48 9·36	+ 2 47·4	4	+36 46 2·4	9·6410	0 7270	P.	*q*
28	10 12 35	+2 22·93	16	10 51 12 86	− 5 0·3	4	+37 14 33 0	9·5685	0·6956	P.	*r*
	10 28 42	+2 24·96	16	10 51 14·89	− 4 39·1	4	+37 14 54·2	9·5871	0·6128	S.	*r*
29	11 6 34	−1 44·04	20	10 54 32·52	+11 5·7	5	+37 44 18·9	9 6226	0 6542	P.	*s*
	...	+3 28·12	20	10 54 32·66	− 14·0	5	+37 44 19·7	...	...	P.	*t*
30	10 55 28	+3 57·05	16	10 57 37·02	− 2 41·6	4	+38 10 32·5	9·5534	0·5546	P.	*u*
	...	−3 25·77	16	10 57 36·85	−10 2·2	4	+38 10 30·7	...	...	P.	*v*
31	10 36 20	−1 56·53	20	11 0 35·47	+ 1 10·6	5	+38 34 59·9	9·6053	0·6073	P.	*w*
	11 19 5	−1 51·22	20	11 0 40 78	+ 1 52·6	5	+38 35 41·9	9·6371	0·6646	S.	*w*

1894.	Liverpool Mean Time of Observation.	☄−✶ R.A.	No. of Comparisons (α).	Apparent R.A. of ☄.	☄−✶ Declination.	No. of Comparisons (δ).	Apparent Declination of ☄.	Log Factor of Parallax in (α).	Log Factor of Parallax in (δ).	Observer.	Star of Reference.
	h m s	m s		h m s	′ ″		° ′ ″				
June 6	10 15 40	+1 14·72	Ret.	11 16 59·60	+ 5 20·6	Ret.	+40 30 16·4	9·6508	0·6520	P.	*x*
20	10 22 7	+ 26·29	,,	...	+ 3 0·2	,,	...	9·6471	0·5819	P.	...
21	10 40 0	−5 6·60	,,	11 50 29·59	+ 2 42·3	,,	+42 52 10·6	9·6814	0·6228	P.	*y*
22	11 16 10	−1 10·70	,,	11 52 31·97	− 6 21·7	,,	+42 57 7·8	9·6784	0·6699	P.	*z*
	11 35 40	−1 9·10	,,	11 52 33·57	− 6 17·1	,,	+42 57 12·4	9·6820	0·6974	S.	*z*
25	10 59 40	−3 21·79	,,	11 58 22·62	− 5 34·4	,,	+43 9 34·1	9·6766	0·6525	P.	*α*
	...	+4 40·07	,,	11 58 22·70	+ 6 4·2	,,	+43 9 33·6	...	...	P.	*z*
27	10 55 30	+ 29·10	,,	12 2 13·49	+ 0 59·2	,,	+43 16 7·7	9·6773	0·6512	P.	*α*
28	10 56 22	+2 22·82	,,	12 4 7·20	+ 3 51·2	,,	+43 18 59·7	9·6787	0·6500	P.	*α*
29	11 5 32	+4 16·78	,,	12 6 1·13	+ 6 14·0	,,	+43 21 22·5	9·6821	0·6714	P.	*α*
	11 7 0	− 35·75	,,	12 6 1·33	− 9 21·2	,,	+43 21 20·2	9·6825	0·6735	P.	*β*
30	10 53 48	+1 14·64	,,	12 7 51·72	− 6 53·2	,,	+43 23 48·2	9·6798	0·6568	P.	*β*
	...	−4 14·88	,,	12 7 51·67	+ 0 42·3	,,	+43 23 51·5	...	...	P.	*γ*

Notes.

May 4.—Frequently interrupted by passing clouds. The comet was earlier compared with W.B. 652, but the R.A. is very discordant. Probably the difference of declination was too great for a trustworthy observation. The Right Ascension in the Radcliffe Catalogue, 1890, differs, however, some ten seconds from W. B. I have no means of determining whether this be due to an error in either catalogue, or to proper motion in the interval, 1890 November 23. May 7.—Definition very bad; star images blurred. May 18.—Moonlight troublesome. June 6.—The observation not considered satisfactory; sky hazy.

Mean Places of Stars of Comparison.

Star's Designation or Authority for Places.	Mean R.A. 1894·0.	Corr. to Apparent R.A.	Mean Declination 1894·0.	Corr. to Apparent δ	Letter of Reference.
	h m s	s	° ′ ″	″	
Paris Catalogue, No. 10304	8 19 17·98	+0·52	− 3 24 26·6	−2·7	*a*
Brad. 1197. Berliner Jahrbuch	8 20 21·81	+0·52	− 3 33 38·8	−2·7	*b*
Glasgow 70, No. 2327, Paris No. 11121	8 57 36·58	+0·81	+ 7 14 0·3	−0·5	*c*
Paris Catalogue, No. 11477	9 14 1·58	+0·96	+13 22 11·9	+1·1	*d*
Glasgow 70, No. 2410	9 15 31·33	+0·97	+13 33 49·3	+1·1	*e*
W.B. (2) IX., No. 450	9 23 32·65	+1·04	+15 50 5·2	+1·6	*f*
Bonn Zones, Vol. VI. +20°, No. 2365	9 36 38·83	+1·16	+20 27 0·9	+2·7	*g*
Paris Cat., No. 11958; Glasgow 70, No. 2524	9 37 26·40	+1·18	+20 40 39·4	+2·7	*h*
W.B. (2), IX., No. 1217	9 59 28·62	+1·35	+27 0 19·6	+4·1	*i*
Bonn Zones, Vol. VI. +27°, No. 1850	10 1 51·03	+1·37	+27 11 10·1	+4·1	*j*
Paris Catalogue, No. 12473	10 5 34·11	+1·40	+28 21 59·6	+4·3	*k*
„ „ 12654	10 14 39·06	+1·46	+29 28 30·9	+4·4	*l*
Leiden, Ast. Ges. Zones, 287, 288	10 23 21·92	+1·53	+32 32 54·7	+5·1	*m*
„ „ „ 169, 281	10 26 29·26	+1·55	+32 30 8·3	+5·0	*n*
Lund, Ast. Ges. Zones, 163	10 37 32·77	+1·63	+35 3 57·3	+5·3	*o*

Star's Designation or Authority for Places.	Mean R.A. 1894·0.	Corr. to Apparent R.A.	Mean Declination 1894·0.	Corr. to Apparent δ	Letter of Reference.
	h m s	s	° ′ ″	″	
Bonn Zones, Vol. VI. + 35, No. 2174	10 36 3·32	+ 1·62	+ 35 4 3·8	+ 5·4	*p*
Lund, Ast. Ges. Zones, 188, 192	10 48 56·92	+ 1·69	+ 36 43 9·4	+ 5·6	*q*
,, ,, ,, 163, 174, 176	10 48 48·25	+ 1·68	+ 37 19 27·5	+ 5·8	*r*
,, ,, ,, 195, 198	10 56 14·84	+ 1·72	+ 37 33 7·6	+ 5·6	*s*
,, ,, ,, 174, 176	10 51 2·86	+ 1·68	+ 37 44 27·9	+ 5·8	*t*
,, ,, ,, 174, 176	10 53 38·25	+ 1·72	+ 38 13 8·3	+ 5·8	*u*
Bonn Zones, Vol. VI. + 38°, No. 2210	11 1 0·88	+ 1·74	+ 38 20 27·2	+ 5·7	*v*
Lund, Ast. Ges. Zones, 174, 176	11 2 30·27	+ 1·73	+ 38 33 43·5	+ 5·8	*w*
W.B. (2) XI., No. 243	11 15 43·08	+ 1·80	+ 40 24 50·0	+ 5·8	*x*
,, ,, 1048	11 55 34·35	+ 1·84	+ 42 49 23·0	+ 5·3	*y*
Bonn Zones, Vol. VI. + 43, No. 2172	11 53 40·85	+ 1·82	+ 43 3 24·1	+ 5·4	*z*
W.B. (2) XI., No. 1183	12 1 42·60	+ 1·81	+ 43 15 3·2	+ 5·3	*α*
W.B. (2) XII., No. 95	12 6 35·30	+ 1·78	+ 43 30 36·2	+ 5·2	*β*
W.B. (2) XII., No. 198	12 12 4·76	+ 1·77	+ 43 23 4·2	+ 5·0	*γ*

E *Liverpool Observatory:*
1894 *November* 6.